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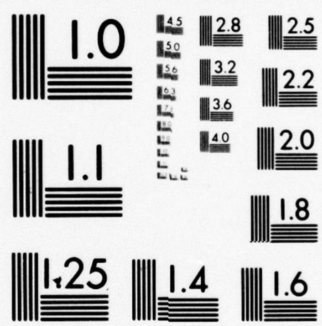

MICROCOPY RESOLUTION TEST CHART

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SVIC NOTES

With this issue we complete another year and come to the end of a decade. This is the Annual Index issue. It is, in effect, a measure of our accomplishments in the DIGEST during the past year. Look at it critically with a view to guiding us in our future efforts. Our goal is to provide a useful current awareness journal in the shock and vibration field. Any suggestions on how this can become a better publication would be most welcome. Furthermore, if you see an item or an article in the DIGEST which you consider wrong, or your viewpoint differs from that of the author, let us know about it. Letters to the Editor are often the beginning of fruitful interchange.

It seems appropriate to look at some highlights of SVIC activities during 1979. Our "International Survey of Shock and Vibration Technology" was published and seems to have been well received. This survey is being extended to countries not covered in the original effort. The 49th Shock and Vibration Bulletin has been printed and distributed. The 50th Symposium in Colorado Springs was a definite success, with about 325 in attendance. Our thanks to the hosts -- the Air Force Flight Dynamics Laboratory and the U.S. Air Force Academy -- for providing the support to make this possible. As you read this column, SVM-11 -- a monograph on calibration of shock and vibration transducers -- will be available. A monograph on the balancing of rotating machinery is expected to be available before the end of the fiscal year. All of these publications may be purchased from SVIC.

In September, I had the privilege of serving as Acting Chairman of Committee TC108 of the International Standards Organization in Moscow. This committee is concerned with international standards on vibration and shock. At the Moscow meeting, I was able to establish dialogue with several Soviet experts on shock and vibration with a view to opening direct channels for interchange on technical matters of mutual interest. The prospects are promising and I will keep DIGEST readers informed on any significant progress.

Plans are afoot to establish a stronger link between SVIC and other DoD information analysis centers. Details are not yet worked out, but direct discussions within the IAC community on goals, methods of operation, and mutual problems should result in better information service from all sources. This becomes increasingly important with the realization that timely availability of technical information plays an important role in the new thrusts to spur innovation and increase productivitity.

I am pleased to announce that Mrs. Carol Healey is assuming a principal role in customer relations at SVIC. Many of you know Carol from the symposia. She is pleasant and efficient, and now becomes your first contact relative to SVIC services and publications. I know that she will see that your needs are met.

As we close out the year, I extend my personal best wishes to all DIGEST readers for a happy holiday season and a prosperous new decade.

H.C.P.

EDITORS RATTLE SPACE

THE PLENARY SESSION

The 50th Shock and Vibration Symposium was successful because it was well planned by the staff and technical advisory group of the SVIC. Although a full report on the meeting will appear next month, it is worthwhile to assess the value of the plenary session at this technical meeting.

A number of plenary sessions were held during the Symposium. These sessions, scheduled before the regular technical sessions, featured lectures by established shock and vibration engineers. The Elias Klein Memorial Lecture -- newly instituted by the SVIC to commemorate its founder -- was given in one plenary session. The plenary lectures -- each about one hour in length -- were used by the speakers for different purposes: technology review, prediction of future events, discussion of advanced technical concepts, and historical perspectives. Each of the four speakers selected a topic within the scope of his technical interest.

The plenary lectures provided continuity and added an atmosphere of formality to the Symposium usually evident only in the opening session -- which has always been more formal than that of any other technical meeting. Not only were the plenary sessions interesting but they also contained valuable new technical information and insights not typical of technical papers.

In my opinion, the plenary sessions at the 50th Shock and Vibration Symposium provided a new and effective way for technology transfer. I hope that more engineers will have the opportunity to participate in such lectures in the near future.

R.L.E.

VEHICLE-GUIDEWAY INTERACTION PROBLEMS

J. Genin* and E.C. Ting**

Abstract - This article discusses three general methods for studying vehicle-guideway interaction problems: moving force approximation, massless guideway approximation, and moving mass approximation. The trolley problem at the Sandia Laboratories is also summarized.

This article is an update and extension of a previous literature review on the dynamic interaction of bridge structures and vehicles [1]. The first review focused on the effects of the kinematical coupling that occurs as a vehicle traverses a flexible guideway. The mathematical difficulties of the problem were discussed, and suitable methods for analyzing the resulting boundary value problem were reviewed. A summary of the traditional modal expansion technique and an algorithm capable of handling a variety of vehicle-guideway interaction problems were also given.

Before the advent of high-speed digital computers the prime concern in studies of the vehicle-guideway interaction problem was proper treatment of the kinematical coupling term that arises in the mathematical formulation of the problem. Physically, the coupled or mixed derivative term arises when the effect of the transverse inertia of the vehicle on the dynamical properties of the system is accounted for. When this effect is considered, the resulting boundary value problem is commonly referred to as the moving mass problem.

Much of the earlier research on vehicle-guideway problems involved attempts to obtain closed-form solutions to serve as design aids. The methods of solution were generally within the mathematical framework of modal expansion and linear transformation techniques. Because these basic techniques are not readily amenable for handling the coupling terms, however, the effects of the vehicle inertia term were often ignored in the analysis. When these effects are ignored, the boundary value problem is commonly called the moving force approximation. Some techniques neglect the inertia effects of the guideway. This assumption is frequently made in studies of the response of a vehicle traveling on a lightweight structure, such as a cable. The foregoing are extreme approximations in modeling the vehicle-guideway interaction problem.

Although modern computational techniques have eliminated the need for many of the limitations and simplifications previously imposed – especially in modeling the physical system – the work of many researchers seem to be traditional. The majority of studies are attempted either to extend the sophistication of the field equations or to include more complex forcing functions and boundary conditions. A moving force approximation is usually assumed, and a modal expansion technique is used as a solution method. Although modal analysis can be incorporated with iterative processes to accommodate the inertia effects of a vehicle, serious drawbacks in numerical calculations and limitations in practical applications exist. Detailed discussions of these points are available [1]. It has become increasingly doubtful that future developments based on the classical approach can be incorporated into engineering design and synthesis procedures, particularly as computational facilities become more readily available and more precise modeling is required for the simulation of a physical system.

GENERAL METHODOLOGY

Moving force approximation. There is sufficient justification for using the moving force approximation, provided its limitations are understood. The moving force approximation provides an adequate model for the moving mass problem if the order of magnitude of the transverse acceleration

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term is insignificant compared to the static inertia term of the traversing vehicle. Such cases arise when the vehicle is traveling at a low speed and the vehicle mass is a much smaller value than that of the guideway. The moving force approximation has been applied to design charts (e.g., Cooper loadings) and dynamic impact factor tables (as found in various bridge design codes) that have been developed to analyze the dynamic characteristics of highway and railway bridges.

A summary of early pre-computer work on the moving force approximation is available [2]. An excellent account of the evolution of the concept of dynamic impact factors has been published [3].

In the majority of early moving force studies, the guideway was modeled as a Bernoulli-Euler beam with simply-supported end conditions. Concentrated and uniformly distributed forces were used to model the vehicle loads.

Most recent developments are extensions of these analyses and simulate the dynamic heave response of new vehicle concepts for high-speed ground transportation and personal rapid transit systems. Vehicle suspension systems in particular are being considered to obtain more precise models. A typical model usually contains a set of sprung masses (passenger compartment), a set of unsprung masses (chassis), linear elastic springs, and linear viscous dampers. This discrete model is flexible and can represent a wide range of suspension designs -- wheels, magnetic suspensions, and air-cushioned suspensions [4-7]. Although the inclusion of the suspension system complicates the analysis, the basic formulations remain linear and uncoupled. Hence, modal analysis yields excellent results.

As indicated above, another area in which considerable attention has recently been focused is improvement of the mathematical descriptions for the forcing functions -- effects of surface roughness and irregularities occurring in the guideway [8-10] - on the vehicle guideway system. Numerical results have also been obtained for vehicles traversing multispan, simply-supported, and continuously supported guideways [10-15].

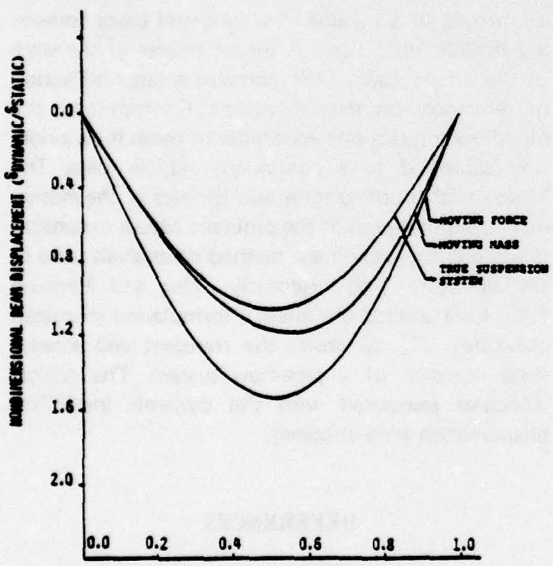
Analyses that include more novel guideway models have also been considered. Guideways modeled by sophisticated beam theories or foundations without tensile resistance have also been studied [16, 17] but are usually complex and appear to have limited application.

A series of interesting problems recently considered [18-20] involves horizontally curved guideways with tandem vehicle loads. Dynamic amplifications of the critical moment and the rotation angle of the curved guideway can be as much as five times that of the corresponding static values. Further, above a critical traversing speed, multiple curved span responses can be several times higher than those occurring for single spans. Data were substantiated with scaled model tests. The dynamic effects for angular motion of the guideway are apparently considerably higher than those for heave motion; it would seem, therefore, that further studies in this area of angular motion for two-dimensional guideway structures are warranted.

Massless guideway approximation. The massless guideway approximation is the limiting case for a large vehicle mass/guideway mass ratio. Mathematically, such approximations do not lead to computational advantages when such techniques as modal expansion, finite differences, finite elements, and Fourier series expansions are used [11, 21-24], especially when high vehicle traversing speeds are considered. Thus, in those cases in which the moving force approximation is not valid, the massless structure approximation is a poor choice for a mathematical model.

A physical system that naturally fits the category of a massless guideway is a cable car traversing a taut cable. Although the formulation of the problem is simplified by eliminating the cable inertia effect, the resulting analysis can become more difficult if a modal expansion technique is attempted. This is so because the lack of bending rigidity in the cable results in discontinuities similar to those found in transverse wave propagation problems. Wave solutions for a mass traversing with constant velocity have been obtained [25, 26]. Kanning [27] recently studied the problem using both a polynomial expansion and an integral formulation previously introduced [1, 28]. Because the integral formulation employs an influence function that can incorporate the discontinuities in the deflection shape, it has distinct advantages in the computational process.

Moving mass approximation. With the moving mass approximation two distinct categories of mathematical models must be differentiated. One model (the classic moving mass problem) disregards the effects of the vehicle suspension system when the transverse inertia terms caused by the vehicle-guideway interaction are considered. The other model accounts for the effects of the vehicle suspension system in the derivation of the transverse inertia terms. The difference in the two models is demonstrated in the figure; the two problems are solved for a consistent set of vehicle and guideway parameters, and the guideway deflection is plotted as the traveling vehicle passes the three-quarter span point. For comparative purposes the moving force solution is also presented in the figure.



Transverse Displacement of a Simply Supported Beam as the Traversing Vehicle Passes the Three-Quarter Span Point. Vehicle Speed = 90 m/s. Mass of Vehicle/Mass of Guideway = 0.67

The trends shown in the figure are consistent for all cases [28, 29]. They become more pronounced when higher mass ratios and/or vehicle traversing speeds are considered. Note that the traditional design procedure, the moving force approximation, leads to the largest deformations -- hence the largest stresses -- in the guideway. When the true suspension system is considered, the lightest guideway design is feasible. Note also that the moving force approximation yields an undesirable (and incorrect) condition: that the maximum deflection occurs at approximately mid-span.

These results were obtained using an algorithm developed by the authors [28, 29]. Other relatively recent efforts dealing with problems associated with the vehicle guideway problem are available [30-34].

SANDIA'S TROLLEY PROBLEM

An interesting physical problem, known as Sandia's trolley problem, has recently attracted much attention; it falls in the category of a moving mass problem. The Shock Simulation Department of Sandia Laboratories, Albuquerque, New Mexico, has utilized a cable trolley system to perform aerial experiments [35]. Trolleys carrying various payloads are launched from fixed positions at selected times and travel predetermined paths along a steel cable.

The steel cable, which has a diameter of 35 mm and a fracture strength of 750 kN, is stretched across a 1.5 km wide canyon. One end of the cable is anchored to a rock outcrop; the other end continues over a supporting sheave and down to a hoisting winch. The winch is used to control the tension in the cable and to position the cable to desired sag dimensions. For example, a tension of 490 kN yields a sag of 30 m and results in a cable transverse wave speed of 307 m/s.

The trolley-cable interaction problem is an interesting analytical study because, in contrast to the usual low, constant velocity assumption, the vehicle moves at a high velocity that varies as a function of time. Further, the sag is such that the static cable shape plays an important role in the dynamic response of the vehicle. In Sandia's initial studies [36, 37], the dynamics of a cable with an accelerating force were adopted to obtain an approximate solution. In the first study [36], the inertia of the moving mass was neglected, and the mass was modeled as a constant force. The second study [37] accounted for part of the inertial effects; the mass was modeled as a constant force plus a force proportional to the square of the vehicle velocity (an inertia term). The inertia was thus approximated as the centrifugal force due

to a mass traversing a constant curvature represented by the static cable shape. The moving mass considered in the study was small compared to the cable mass, so that this approximation gave reasonable results up to a fairly high velocity.

In a recent field test, a sudden and dramatic cable failure occurred as a trolley was accelerated through the transverse wave speed of a cable. A movie of the incident showed a sharp kink in the cable between the two supports of the trolley. Analysis of the system, accounting for the inertia of the moving mass [38], revealed that, when a mass is accelerated or decelerated through the transverse wave speed of an ideal string, two oppositely-traveling discontinuities are propagated in the string. These discontinuities are not predicted by the moving force analysis; thus, it is necessary to include all the kinematical terms representing the trolley-cable interactions.

The foregoing problem has also been considered by Ting and Kanning [39]. They used an integral formulation [27] that proved to be efficient and accurate.

OTHER MATHEMATICAL TECHNIQUES

The basic methods of analysis previously reviewed [1] were the modal analysis, finite difference, finite element, and series expansion methods. Two other mathematical techniques are worthy of comment: the modeling technique known as bond graphs [40] and use of the computational tools known as Lagrangian multipliers [41].

Bond graphs in essence represent a subtle alternative to the conventional technique of free body diagrams for developing the equations of motion of a system. Originally the technique found great favor among researchers in automatic controls because of its similarity to the conventional block diagram procedure. The method itself is related to a concept known as a mathematical tree [42, 43]. A variety of applications for bond graphs have been given [44]; papers on current applications to mechanical systems are available [45, 46].

The Lagrangian multiplier technique is, in a sense, another bond graph form [47]. The equations of motion for each component of the system are developed for each free body diagram; the interaction forces, or Lagrangian multipliers, are represented as external forces on the system. With the appropriate constraint equations a numerical procedure can be developed to determine the interactive forces at each point in time. An interesting feature is that the constraint equation can be written in terms of an error function that can be minimized numerically.

RELATED DYNAMIC INTERACTION PROBLEMS

A class of fluid problems lends itself to the same mathematical framework as the vehicle-guideway system. Included are problems of pipe structures submerged in a parallel flow field and pipes conveying laminar fluid flow. A recent review of the state of the art by Chen [48] contains a large collection of references on these problems. Conceptually, the pipe-flow interactions are similar to those for a guideway subjected to a continuous vehicle mass. The kinematical coupling term also appears in the mathematical formulation of the problem. Modal expansion is again the predominant method of analysis used in the literature [49]. Recently, Ting and Kanning [50] have applied the integral formulation discussed previously [1] to study the transient and steady-state response of a pipe-flow system. The critical velocities associated with the dynamic instability phenomenon were obtained.

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LITERATURE REVIEW

survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains review articles on flow-induced vibration of nuclear reactor fuel; and a survey of structural optimization under dynamic constraints.

Dr. M.W. Wambsganss and Dr. T.M. Mulcahy of Argonne National Laboratory have concluded their two-part article on flow-induced vibration of nuclear reactor fuel. Part II covers design considerations.

Dr. M.A.V. Rangacharyulu of the Birla Institute of Technology & Science, Pilani, India, and Professor G.T.S. Done of The City University, London, have co-authored an article which reviews the literature since 1970 on structural optimization under dynamic constraints. Methods used with continuous and discrete modes are described for free vibration problems. Methods for forced vibration problems and nonconservative problems are also discussed.

FLOW-INDUCED VIBRATION OF NUCLEAR REACTOR FUEL
Part II: Design Considerations

M.W. Wambsganss and T.M. Mulcahy*

Abstract - This two-part article focuses on the role of reactor fuel in flow-induced vibrations in nuclear reactors. Part I is on mathematical modeling of the fuel assemblies. Part II describes design considerations.

DESIGN EVALUATION VIBRATION TESTING

It is generally necessary to resort to testing for final evaluation of each new component design from the standpoint of flow-induced vibration. Although reduced geometry scale models are often employed to investigate the potential for flow-induced vibration, fuel assemblies, because of their more manageable size and readily achievable flow-rate requirements, lend themselves to full-scale testing. Despite the fact that fuel assembly tests are full-scale, out-of-pile design evaluation tests, in general, must be considered as model tests, for, even in those cases in which the fuel assembly is prototypic, the environmental conditions are generally not simulated. Water, for example, is typically used to simulate sodium; air-water mixtures are used to simulate the two-phase flow condition associated with boiling; and air is often used to simulate CO_2 or helium. In addition, the model tests are often performed at ambient temperatures and, of course, radiation and relative thermal expansion effects are not present. Consequently, test results must be extrapolated to reactor operating conditions, or, if possible, the tests must be shown to be conservative.

Design evaluation tests are generally carried out using prototypic fuel rods with simulated fuel pellets; depleted uranium and lead pellets have been used. Water is typically used as the test fluid in the evaluation of PWR (pressurized water reactor) and fast (sodium-cooled) reactor fuel assemblies; air-water mixtures are often used to simulate the two-phase (steam-water) flow that occurs in BWRs (boiling water reactors) and reactors of the CANDU-BWR (Canadian deuterium uranium-boiling water reactor) type. Instrumentation includes accelerometers, strain gages, and velocity sensors for measurement of pin motion. Tests are carried out to evaluate specific designs; parameter studies are used to evaluate the effects of particular design features. Because of the complexities involved and the differences in fuel assembly designs, results from one test are usually not directly applicable in the design evaluation of another assembly. Nevertheless, results from different tests do provide insights and trends that are useful in test design and in the analysis and interpretation of results.

The design evaluation of fast reactor fuel assemblies has been reported [59, 64-66].** Both grid spacers [59, 64, 65] and wire wrapped spacers [66] are included. Hess et al [65] have reported the results of endurance tests in sodium at temperatures to 650°C (1200°F). Kinsel [66] has reported on full-sized, 217-pin fuel assembly tests in water at temperatures of 38°C, 76°C, and 93°C (100°F, 169°F, and 200°F); 93°C (200°F) water closely simulates the viscosity of sodium at reactor operating temperatures. Kinsel found that pin vibration response is essentially unaffected by fluid temperature. Irradiation tests of wire-wrapped fuel bundles in EBR-II have shown that wear occurs between fuel pin and wire wrap; the wear has been correlated with fuel-pin-bundle porosity [67], which is computed as the difference between the inside dimension of the fuel duct and the theoretical dimension of the fuel pin bundle, divided by the number of rings of fuel pins making up the bundle; porosity is given in distance/ring. The greater the bundle porosity the greater the wear.

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****For a complete list of References, see the November, 1979, issue of the* Digest.

The proprietary nature of the light water reactors has limited the information available on designs and test results. As new fuel assemblies evolve, design evaluation testing is performed but usually only the fact that tests have been done is published in the open literature [68]. In an early study, Pavlica and Marshall [69] performed tests on a PWR 4 x 4 assembly of fuel rods with spacer grids of the spring type. They investigated the effect of the number of spacers and temperature (70°F and 150°F) on rod response; results showed that the temperature effect was not great. Carmignani et al [70] also performed tests on a 4 x 4 rod bundle of a BWR design. Six different assembly configurations were tested to evaluate the effect of spacer position, number, and design on rod response. Vibration amplitude decreased as the number of spacers increased. Results were compared with predictions using available empirical correlations [11, 62, 63]; for one test configuration reasonable agreement was achieved. Walton et al [38] have reported the results of in-core monitoring; fuel assembly lateral frequency decreased due to irradiation effects.

A large amount of work has been reported on the CANDU reactor fuel [33, 71-74]. The CANDU fuel assembly design is unique in the sense that the fuel rods are assembled in fuel bundles that are loaded end-to-end on a central support to form what is called a fuel string. Forrest and Hancox [71] investigated the effect of support structure motion as a source of excitation for the fuel string. Their test results indicated an apparent reduction in the effect of mechanical excitation as the flow was increased; at flow velocities above 13 m/s the measured motion was determined to be due to fluid excitation; the mechanical excitation effect was negligible. Card [72] studied the effect of upstream noise generators and determined that they have an important effect. Forrest and Monti [33] used steam-water flow introduced at the inlet to simulate two-phase flow, which occurs at the outlet of the fuel string; rms-displacement increased with quality, peaking at 13%; reducing axial tension resulted in a considerable increase in lateral response.

At the 1973 Conference on Vibration Problems in Industry a group of papers [75-79] had to do with the design evaluation of the AGR (advanced gas reactor) fuel. The papers discuss the effect of roughness on flow-induced vibration response [75], the effect of reactor noise as simulated by loudspeakers [76], vibrations during on-power loading [77], and full-scale testing [78, 79]. The gas coolant in the AGR is CO_2; Whitton and Hammill [80] have discussed the differences in vibration response resulting from the use of CO_2, helium, and air as test fluids.

The measurements involved in design evaluation testing are often difficult and require state-of-the-art instrumentation, particularly small and relatively sensitive equipment; for in-reactor testing, survival at high temperatures and in a radiation environment are also required. Miniature accelerometers, strain gages, and variable reluctance transducers have been used; many of the references given above include discussions of instrumentation and measurement techniques; in some cases the descriptions are detailed. More exotic methods of detection involve the use of neutron flux measurements as an indicator of fuel rod motion [81, 82].

VIBRATION DAMAGE

A significant amount of work has been devoted to the mathematical modeling of parallel flow-induced vibrations, the measurement and characterization of the pressure field, the development of empirical prediction methods, and the performance of laboratory and in-reactor tests to measure fuel rod response in particular fuel assemblies. After the response has been characterized, the next very difficult step is to relate the vibration response to damage and to develop a set of acceptance criteria. Because of the small amplitudes of parallel flow-induced vibration, fatigue is generally not a failure mechanism of concern. Rather, fretting/wear is the failure mechanism of most importance [3, 4] because of inherent clearances between reactor fuel rods and support grids, or between fuel pin and wire wrap. Several papers [67, 76, 78, 83-85] refer to fatigue and wear assessments but, for the most part, do not contain details. An exception is Schmugar [84, 85] who discusses wear theory and models and describes a procedure for determining wear from fluid forces and rod response. Although the procedure was implemented and checked with test results, no details are given.

Fretting or wear failure due to parallel flow excitation has not occurred, to the authors' knowledge,

except where defective parts allowed vibration above design levels [4]. Some cross flow is an integral part of fuel assembly heat-transfer design [70]. Only unforeseen components of cross flow have been responsible for fuel element failure by fretting. However, the occurrence of fretting is minimal, and in PWR practice the damaged fuel rods are often operated over their full reactivity lifetime [4].

Prediction of wear from basic pressure field and vibration response data is apparently in the developmental stage. The fuel rods employed in design evaluation tests are usually inspected to determine if a particular design produces abnormal amounts of wear; endurance testing is performed for critical conditions to determine wear rates [3, 70]. However, wear testing is still performed [70] in operating reactors to provide confidence in design. The best assessment of the reliability of a new fuel assembly design is perhaps the performance of a currently operating design.

SUMMARY AND CONCLUDING REMARKS

Nuclear reactor fuel rods are subjected to excitation forces consisting of both fluid-borne pressure fluctuations and structurally transmitted motion imparted to the supports. The structurally-transmitted forces are associated with rotating machinery, such as pumps, and their transmission is highly dependent on the overall system design. The fluid-borne pressure fluctuations include both nearfield and farfield contributions. The farfield contributions are system dependent – they are functions of the pumps and piping arrangement, including valves, elbows, and headers and of the location of these components relative to the inlet to the fuel assemblies. The nearfield contribution is locally generated within the boundary layer and is modified by wake flows from such inherent disturbances as are provided by support grids, spacers, and wire wrap.

Mathematical modeling to predict response via the equations of motion is syymied because the forcing function, which consists of wall pressure fluctuations, must be characterized. Semi-empirical correlations for response are available; however, they are generally accurate only within an order-of-magnitude and consequently are useful only in providing early design guidance. Therefore, designers have found it necessary to resort to full-scale testing for design verification. However, there is uncertainty even in full-scale testing because prototypic conditions of high temperature, radiation environments, and, perhaps most important, system features as they effect structural-borne vibration and farfield noise, are not easily achieved; it is necessary to extrapolate results to operating conditions. Nevertheless, design evaluation tests have proved beneficial in identifying potential problems and in contributing to design modifications and fixes. An area in which relatively little work has been reported is that of predicting fretting/wear based on knowledge of fluid pressures and rod response. Most wear data for new fuel assembly designs are obtained in full-scale flow tests and operating reactors.

In summary, awareness, on the part of the designer, of the potential for flow-induced vibration, coupled with the use of empirical correlations and tests, have resulted in fuel assembly designs that have proved to be reliable and free from flow-induced vibration damage; the authors know of no fuel rod failure caused by parallel flow-induced vibration. In this regard, it is interesting to note that a conclusion of an international working group on fast reactors was (at the time of the meeting) that "it appears that there are not serious vibrations problems existing in LMFBR fuel assemblies" [86]. However, as basic designs change (for example, spacer designs or flow paths) and as coolant flow velocities increase, it becomes necessary to reexamine the potential for flow-induced vibrations using the design tools and background experience available at the time.

There continues to be an active interest in fuel rod/assembly vibration; in particular an International Conference on Vibration in Nuclear Plants held at Keswick, England, in 1978. Unfortunately, the "Proceedings" were not available to the authors in time to include the papers in this review article. Two international conferences have been held this year that included papers on fuel vibration: 5th International Conference on Structural Mechanics in Reactor Technology in August in Berlin, and Symposium on Practical Experiences with Flow Induced Vibrations in September in Karlsruhe, Germany.

A SURVEY OF STRUCTURAL OPTIMIZATION UNDER DYNAMIC CONSTRAINTS

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***Abstract** - This article reviews the literature since 1970 on structural optimization under dynamic constraints. Methods used with continuous and discrete models are described for free vibration problems. Methods for forced vibration problems and nonconservative problems are also discussed.*

Methods of structural analysis have developed tremendously over the past two decades, due mainly to the advent of digital computers capable of speedily handling large arrays of numbers. As confidence has grown in the ability to predict the detailed performance of a structure, so has the desire to improve the design in a systematic way toward the optimum. The need to reduce structure weight without compromising structural integrity is all important in aerospace applications, and much of the motivation behind the development of structural optimization methods has been due to this factor. Furthermore, development has been assisted by making use of mathematical methods drawn from such fields as operations research and optimal control theory.

A well-posed problem of optimal structural design involves specifying:

(i) the purpose of the structure
(ii) the geometric design constraints
(iii) the behavioral constraints
(iv) the design objective, which acts as a basis for choice between acceptable alternative designs

When the problem is expressed mathematically, the constraints become simple bounds on variables in (ii) above, or on functions (iii); the design objective (iv) is expressed mathematically as an objective function to be minimized. Much of the earlier literature was concerned with problems having relatively simple behavioral constraints; e.g., minimum weight design for various static loading conditions. However, papers dealing with the more complicated dynamic constraints have also been appearing in the literature in increasing numbers, and this survey is specifically concerned with this aspect.

Comprehensive reviews covering the whole field of structural optimization are available [1-6]. Reviews on the more specialized aspects, in which dynamic constraints are involved, have also been published [7-9].

The bibliography covered in this review extends mainly from 1970 onward; the greatest volume of work appeared in 1975 and 1976. References are classified according to problem free vibration, forced vibration, and nonconservative systems -- but a range of different methods of optimization applies to each problem. Before the particular problems are considered, the various methods available will be briefly surveyed.

GENERAL METHODS OF STRUCTURAL OPTIMIZATION

The general methods fall into three broad categories:

(a) optimality criterion methods
(b) mathematical programming methods
(c) optimal control methods

In (a) an optimality condition relating to the behavior of the structure is derived; the premise is that when the structure is sized to satisfy this condition, the objective function automatically attains an optimum value. The fully stressed or uniform strength design is an example of the early use of optimality criteria. The methods, which often yield computationally efficient solutions, have been

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extended to dynamic situations. There are some problem areas, however, such as those caused by multiple minima, multiple constraints, and active and passive grouping by members [4]. Methods using iterative schemes derived from the necessary conditions of optimality (Kuhn-Tucker conditions) are sometimes classed as optimality criterion methods even though they are purely numerical in nature.

The mathematical programming methods are applicable to a wide range of problems, of which structural optimization represents only one particular application. The general matrix methods of structural analysis form a mathematical basis on which numerical search procedures are used to progress to the optimum. The capability to deal with all types of objective and constraint functions makes these programming methods very versatile. Textbooks [10-12] provide lucid expositions of various algorithms used in programming techniques. Moe [13] presented a survey of mathematical programming methods with special emphasis on penalty function methods. A recent review [5] examined two important techniques (optimality criteria and programming methods) and related them via a Lagrangian function.

In methods based on the optimal control approach extensive use is made of calculus of variations, but the structure is represented by a continuous model, and the behavior is described by differential equations. The nondiscrete nature of the approach imposes limitations. An advantage is that various questions can be discussed using the continuous approach and optimal control theory: the existence and uniqueness of optimal solutions, the creation of an exact solution as a check for discrete methods, and the development and interpretation of optimality criteria.

Only very recently have optimal control techniques been applied to large framed structures having many members. The basic algorithm for optimization is based on the steepest descent optimal control techniques of Bryson and Ho [14]. A distinction is made between state and design variables associated with the problem, and the variables are related only through the equilibrium equations. The variables are treated independently in the optimization process. This distinction allows the designer to take advantage of efficient structural analysis methods and to eliminate explicit dependence on the state variables through adjoint relationships. Haug and Arora [15] presented a survey of optimal design problems in the area of mechanical systems that can be addressed by this technique. The textbook by Bryson and Ho [14] is an excellent reference for optimal control techniques and the methods used in solving the resulting boundary value problems.

SPECIFIC PROBLEMS

The various problem areas and the methods used in structural optimization under dynamic conditions are described in this section.

Free Vibration Problems

Among the first problems of optimization under dynamic conditions were those involving the free vibrations of simple structural elements and framed structures; minimum weight designs having constraints on the natural frequencies and sectional areas are typically sought. Pierson [7] has given an account of work done during the 1960s; much of it was concerned with the minimization of weight for a specified fundamental frequency. The approach adopted generally depends on whether the system being investigated is continuous or discretely modeled.

Continuous models. A steepest descent method for solving continuous minimum weight problems with a specified fundamental frequency has been applied to a portal-frame design [16]. Weisshaar [17] made interesting observations on the optimum design of simple one-dimensional continuous systems with constraints on higher mode natural frequencies using variational methods. If the reference structure has periodic eigenfunctions, the optimum structure has periodic eigenfunctions. If this is the case and if the eigenvalues are integral multiples of each other, the optimum solutions for higher natural frequency constraints can be generated from the fundamental solution; the weight saving is not a function of which natural frequency is fixed.

Some authors have employed a piecewise uniform approximation to continuous problems [18-21]. Haug, Pan, and Streeter [18], using such an approximation coupled with a steepest descent method, studied frequency constrained minimum weight beams and plates. Cardou [19, 20] treated axial and

torsional vibration of beams, and Sippel and Warner [21] solved flexural vibration problems with frequency constraints using a Lagrangian multipliers approach.

Armand [22] presented an interesting application of a classical distributed parameter optimal control method to plates for fixed fundamental frequency. Minimum weight designs of stiffened cylindrical shells for maximum separation of the two lowest natural frequencies were presented using a sequential constrained minimization technique [23]. De Silva and Grant [24] tackled an interesting problem of maximizing a linear combination of natural frequencies of a turbine disc for a given weight. An optimal control approach was used; computation was via a penalty function approach coupled with a hill climbing technique.

Pappas [25] used a direct search procedure coupled with a gradient-based direction-finding algorithm to study the optimal frequency separation problem for cylindrical shells. Patnaik and Maiti [26] used programming techniques to study the problem of the interaction of different constraints, especially the static instability and natural frequencies of stiffened structures. Weisshaar [27] presented two approximate solutions to frequency-constrained problems for simple structural elements: a shooting technique used in optimal control theory and a perturbation technique. They are suitable for small-scale problems having few design variables.

Haug, Arora, and Matsui [28] used a steepest descent optimal control method to design a minimum weight continuous problem. The method, coupled with constraint error compensation, converges quite rapidly. Pierson [29] used a similar approach of state space formulation and a gradient projection algorithm to design minimum weight beams for fixed natural frequencies. More than one frequency can be constrained.

Elwany and Barr [30] studied some optimization problems in torsional vibration using a variational method with a view to maximize a given natural frequency for a fixed weight, or equivalently to minimize weight for a fixed frequency. Constraints are implemented through Lagrangian multipliers; the resulting nonlinear equations are solved numerically. Cardou and Warner [31] applied an optimality criterion to simple axially vibrating bars and portal frames under frequency and section constraints (the use of the term sandwich structures in the title of this reference is misleading).

Discrete models. Mathematical programming methods and optimality criterion methods are extensively used for the structures represented by discrete models. Attempts have been made to extend optimal control methods to cover these problems. Rubin [32] developed a procedure in which the fundamental frequencies can be subjected to an inequality constraint. The process follows two alternating cycles; initially a steepest descent gradient iteration is used to change frequency until it lies within a prescribed margin. Then the weight is minimized using a steepest descent algorithm. Occasional correction steps using frequency modification cycles are needed to maintain the desired frequency change.

Fox and Kapoor [33] used Zoutendijk's method of feasible directions to solve frequency constrained problems. Setlur and Kapoor [34] presented a parametric differentiation method in conjunction with the penalty function approach. The design is treated as a function of the penalty parameter to determine the appropriate parameter. A sequential method is used that requires both first and second derivatives of the objective function.

Pappas and Amba Rao [25] also proposed a penalty function approach to treat both static and dynamic optimization problems with inequality constraints. The objective function is formulated with an appropriate penalty function; the function is appended so that a reasonably symmetric ridge is created at the acceptable/unacceptable region. A direct search method coupled with a local search technique is used to move along the ridge to the optimum. The method performed very well, but large-scale problems were not tested.

A sequential unconstrained minimization technique involving a variable metric algorithm was used to design large framed structures for a fixed fundamental frequency [35]. The concept of design variable linking was used to reduce the number of variables, thus increasing the efficiency of the optimization process. An extended interior penalty function method was implemented for determining the transition between the interior and extended por-

tions; this method was a powerful algorithm for general inequality constrained problems [36] and can easily be applied to implement frequency constraints. Minimization can be carried out in both feasible and infeasible regions.

Reddy and Rao [37] studied some optimization problems related to machine tool structures represented by finite elements. Minimum weight designs with constraints on natural frequencies and chatter stability were obtained through a penalty function method, thus increasing the scope of application of programming techniques. Schmit and Miura [38] incorporated an efficient combination of finite element techniques and mathematical programming techniques. Several approximation concepts -- design variable linking, constraint approximations, and constraint deletion -- were used.

An energy density criterion has been derived; a recursive relation for the design variables was derived so that the design can be continuously improved [39]. Taig and Kerr [40] also derived an optimality criterion and a related recursive relation. They considered constraints on dynamic stiffness, strength, and sectional areas of members. These methods were very efficient for large structures.

Recently an efficient algorithm [41] has been proposed that is similar to one for mechanical design problems with natural frequency constraints [37]. A similar technique has been used to study the effect of shear formation and rotary inertia on optimum beam designs with frequency constraints [42]. Yoshimura [43] used an energy density optimality criterion to study the design of machine tool structures for minimum chatter conditions and frequency constraints.

An optimal control method using a steepest descent algorithm has been applied to the design of plane frames with constraints on deflection, strength, and natural frequencies [44, 45]. A similar algorithm was used to design mechanical systems [28]. These applications of optimal control techniques to large-scale problems are noteworthy.

Rizzi [46] presented a general procedure for structural optimization with several constraints, including frequency constraints. He used a recursion relation derived from the necessary conditions of Kuhn-Tucker and a procedure to delete the inactive constraints. The method has excellent covergence properties. Flewry and Geradin [47] showed how the optimality criterion method can be interpreted from a mathematical programming point of view and have proposed a generalized form of optimality criterion based on the Kuhn-Tucker conditions of the exact problem. The solution obtained is thus identical to that obtained by mathematical programming for a problem using inverse design variables and linearized constraints.

Arora and Haug [48] developed a hybrid method that combines the best features of both optimality criterion methods and state space gradient projection methods used in optimal control theory. The potential of the method is demonstrated; such hybrid methods may lead to more efficient design procedures.

Recent contributions have appeared in a special journal issue on structural optimization [49-51]. Two general purpose optimization algorithms were applied to a beam axial vibration problem [49]. The Kuhn-Tucker optimality criteria were used in conjunction with the finite element method, with the usual constraints on natural frequencies and design variables [50]. The application is to a thin-walled shaft and a turbine shaft. The use of second order frequency sensitivities in conjunction with SUMT was described [51].

Forced Vibration Problems

The optimum design of shock and vibration isolators is an early example of structural optimization under forced vibration conditions; methods of mathematical programming have been applied [52]. In general, the total structural weight must be minimized subject to constraints on the displacements and stresses, when both are functions of time and the design variables. The displacements satisfy the usual equations of motion that now include forcing terms. The problem is simplified if sinusoidal excitation is considered. Frequency constraints can be included in the formulation.

Mróz [53] and Plaut [54] employed energy methods connected with Rayleigh's inequality to design minimum weight structures under simple harmonic excitations for a specified deflection. A common feature of their approaches is that the forcing fre-

quency is limited from above by the fundamental frequency of the optimal configuration. Similar problems have been examined using optimal control techniques with the frequency restriction removed [55, 56]. Maximum allowable stress amplitude and minimum cross-sectional area constraints were imposed. The analyses revealed that the design space in the absence of damping can contain many disjoint feasible regions and that multiple optima exist. Seireg and Hamad [57] noticed similar features; they used a combination of gradient based search and a univariate search to arrive at the optimum design. State space gradient projection methods [28, 29] do not seem to have been applied to this class of problem, but they can easily be extended.

Some steps have recently been taken to design structures under stochastic loading [58-61]. Rao [58] used standard mathematical programming techniques to design beam and platelike structures under blast and acoustic loading with constraints on the probability of failure. Narayanan and Nigam [59] applied a SUMT method using the gradient method of Fletcher and Powell to design sheet stringer panels subjected to jet noise excitation. They considered constraints on stresses, fatigue life, and natural frequencies. Design in a seismic environment has also been studied [60, 61].

Fox and Kapoor [33] examined some discrete problems described earlier and obtained numerical results for several truss problems. A single sine wave-forcing function was assumed. The objective was to obtain partial derivative information so that efficient minimization techniques could be used. A shock spectral method was used to remove time dependency in the dynamic response constraints. The actual displacements and stresses were replaced by conservative upper bounds.

Cheng and Botkin [62] used a similar approach to design minimum weight damped frames subjected to general dynamic loads. The method of analysis is based on modal superposition; the dynamic amplification factors were obtained from the shock spectrum. The peak dynamic response was constrained. Cassis and Schmit Jr. [63] also studied frame problems; they included the dynamic response quantities treated parametrically in time in the formulation of optimization design problem.

Approximation concepts applied elsewhere [36, 38] have been extended to the dynamic response regime. The realization of the disjoint nature of the design space leads to the choice of an exterior penalty function method incorporating the Davidon, Fletcher, and Powell minimization algorithm. Successful implementation is facilitated by using dummy constraint boundaries and a new approach to the move limit problem. The need for move limitation arises from the use of approximate analysis techniques based on Taylor's series expansions for dynamic response quantities. It has been shown how an interior penalty function can be applied to problems of optimum design for dynamic loads [36].

An algorithm has been presented for studying piecewise uniform structures [64]. Constraints were imposed on displacements, stresses, frequency, and design parameters. The time-dependent constraints were transformed to equivalent functional constraints; a state space steepest descent algorithm (optimal control theory) was used. The same authors [65] have also developed the state space approach to sensitivity analysis and optimization of structures under transient dynamic excitations. The gradient projection algorithm used by Pierson [29] can also be employed on these problems.

An energy density based optimality criterion was used to devise a recursive relation to design large structures subjected to dynamic loading with constraints on displacements and stresses [66, 67]. The aperiodic forcing function was represented by a Fourier integral in determining the dynamic response. The optimality criterion derived for normal modes was used as an approximation to design in the dynamic mode, which is replaced by a combination of normal modes. Sciarra [68] used a recursive relation based on the strain energy distribution to reduce vibratory response for harmonically excited structures with minimum weight penalty.

Nonconservative Problems

A class of problems closely related to problems with natural frequency constraints is that of optimal design with such specific aeroelastic eigenvalues as divergence speed or flutter speed. In general, the earlier attempts to design minimum weight structures for flutter constraints adopted a mathematical programming point of view or applied a Lagrangian multiplier approach.

Several interesting one-dimensional panel and axisymmetric circular cylindrical shell optimization problems, for which the flutter speed is held constant, have been formulated and solved. The design of cantilever columns under follower forces [69-72] falls into the same category. In some early papers various one-dimensional problems were treated using optimal control techniques. The resulting two-point boundary value problem was solved with shooting techniques. Armand and Vitte [73] and Weisshaar [74] used a similar approach to treat minimum weight panel design problems with flutter constraints.

Plaut [75] applied a two-term Ritz procedure to the related problem of maximizing the critical flutter parameter for a given mass of piecewise uniform thick panels. Pierson [76] and Pierson and Russell [77] proposed a discrete approximation to continuous panel problems; finite difference equations and a gradient projection algorithm were used in conjunction with a penalty function technique.

Pierson [78, 79] also used a gradient projection optimal control algorithm incorporating conjugate gradient directions of search to treat the same kind of problem, and Pierson and Genalo [80] extended the method to treat two-dimensional panel problems that fall into the category of distributed parameter optimal control problems. Inplane loads and minimum section constraints were allowed. The algorithm differs from the usual projection operator in optimal control theory in three ways: the requirement for terminal state constraint satisfaction at each iteration, the method of step size selection along projected directions of search, and the treatment of control parameters. It is more efficient than earlier approaches, in which two-point boundary problems that arise from necessary conditions of optimality must be solved; the terminal state values are sensitive to initial guesses of thickness distribution and control parameters.

Several types of mathematical programming methods have been successfully applied to flutter optimization in conjunction with finite element formulation. Craig [81] used a gradient projection algorithm to design a supersonic panel with a flutter constraint. Rudisill and Bhatia [82, 83] used a gradient search technique incorporating an approximate sequence of gradient searches that increase flutter velocity and a gradient mass search that reduces flutter velocity; when the desired velocity is reached, a gradient projection algorithm maximizes the flutter speed at constant mass. This is similar to the process of Rubin [32] for frequency constraints. Simodynes [84] used a similar approach. In these procedures the step size in the search is arbitrary. Rao [85] has an interior penalty function method to design large structures to a flutter constraint.

Haftka [86, 87] used the same method in the context of continuous flutter constraints, which are treated as parametric constraints. The idea of an equivalent minimum constraint was used to simplify the problem. Gwin and Taylor [88] used a feasible direction method, and Craig and Erbug [89] proposed a gradient projection algorithm to study minimum weight flutter constrained problems. Special features were the use of analytical expressions for gradients (calculated only for active constraints), constraint tolerances, and a return vector for whenever constraints are violated. These speed up convergence. Weisshaar [90] also used a gradient projection method based on a Fletcher-Reeves conjugate direction search with a refined finite element formulation. Phea and Chi [91] employed approximations in the general nonlinear programming problem and then applied linear programming techniques.

A search technique with a defined step size has been presented for the minimization of mass for fixed flutter speed [92]. The flutter speed was exactly satisfied at each resizing step; step size was determined by a direct minimization of mass for each set of flutter derivatives calculated. Niblett [93] investigated three different mathematical programming approaches based on gradient projection; he applied the most economical to a swept wing example. A number of philosophical questions relating to flutter optimization were also addressed.

Several researchers have employed optimality criterion techniques to solve flutter optimization problems. The important steps are the derivation of necessary conditions to be satisfied by a locally optimum design and a recursive procedure to realize these conditions. Pines and Newman [94] derived a rigorous optimality condition for flutter-constrained minimum-weight design problems. The energy density criterion thus derived can be viewed as the nonconservative equivalent of the Lagrange energy density optimality criterion [39]. An iterative

scheme was used to arrive at the optimum design. Newman's work is significant in that he used an integral formulation; the iterative procedure for satisfying the optimality criterion is integrated with the flutter solution, thereby improving the efficiency. Taig and Ker [40] developed a resizing algorithm based on a general optimality theorem to design flutter constrained structures.

Wilkinson et al [95] also used an optimality criterion method. They examined several ad hoc optimality criteria. They obtained a uniform flutter velocity derivative criterion for flutter critical elements and a fully stressed design criterion for strength critical elements. Their approach provides a design for both flutter and strength constraints.

Segenerich and McIntosh [96] used a hybrid method that is essentially a direct numerical search technique having the direction of move related to the optimality criterion. Haftka et al [97] presented a comparative study of optimality criterion-based methods and programming methods for flutter optimization; the former methods were rated better. McIntosh and Ashley [98] developed an heuristic design algorithm based on an optimality criterion and compared the results to those obtained by a search scheme based on the method of feasible directions. They too considered that the former technique was a better candidate for large structures with multiple constraints. They also showed how the optimality criterion might be constructed when the aeroelastic constraint is written in the time domain. Their work suggests that complete mathematical rigor is not always necessary in a procedure for design optimization.

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BOOK REVIEWS

STABILITY THEORY AND ITS APPLICATIONS TO STRUCTURAL MECHANICS

C.L. Dym
Noordhoff, 1974

This short, interesting text is a good introduction to some of the modern stability methods for continuous structures. Applications are sprinkled throughout. The material is suitable for self study or for a graduate engineering course.

In the author's words, "...the book has three principle parts: 1) The development of the Lyapunov direct method and of the minimum energy principle for discrete systems; 2) Analogous development of the Lyapunov functional method and of the minimum energy approach for continuous systems; 3) Applications." In particular, the analysis of imperfection sensitivity as pioneered by Koiter and elaborated by Budiansky and Hutchinson is carried out for a number of simple examples including columns, arches, and circular and rectangular plates.

Again, in the author's words, "...we intend to be informal rather than rigorous in our presentation." This is an attractive feature of the book but has, perhaps, led to sloppiness in some of the mathematics. For example, in the analyses of three different problems on pages 37, 38, and 41, the author states that the time derivatives of certain Lyapunov functions are negative definite whereas, in fact, they are only negative semi-definite as functions of all the state variables. To include asymptotic stability in this case one must invoke the notion of invariant sets.

In summary, Professor Dym has given us a concise, up-to-date introduction to some of the newer practical methods for the stability analysis of structures.

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AN INTRODUCTION TO OPTIMAL ESTIMATION OF DYNAMICAL SYSTEMS

J.L. Junkins
Sijthoff & Noordhoff International Publishers
B.V. Alphen an den Rijn, The Netherlands, 1978

The text presents a carefully developed theory and numerous applications of estimation of dynamic systems. Examples are used throughout to describe the class of problems being discussed and to illustrate use of the computational algorithms that are developed. The examples range from simple, but applicable, idealizations to realistic problems. Statistics of measurement error are accounted for in each class of problems treated.

An introductory chapter on least square approximation develops the least squares method for both batch and sequential data. Linear systems are introduced with examples; necessary and sufficient conditions for optimal estimation are derived. Batch problems are treated, including constraints that zero error shall occur in selected observations. Sequential data are then treated and several forms of state update equations derived. Finally, nonlinear estimation is introduced and least square differential correction algorithms are derived.

The second chapter is devoted to a brief and somewhat more rigorous treatment of minimum variance estimation. Optimum state estimation matrices are derived, both with and without a priori estimates of the state and its co-variance matrix. Selection of the weighting matrix in the least square method to provide minimum variance estimation is discussed.

Applications of parameter estimation methods are presented in the third chapter. Planar triangulation and spacecraft trajectory and orientation determination are treated as elementary to moderately complex examples. Modeling the earth's topography and modeling gravitational potentials are presented as more challenging examples.

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An introduction to the theory of ordinary differential equations is provided in Chapter 4 in preparation for dynamic systems. Reduction of arbitrary ordinary differential equations to first-order form is discussed. Differentiability of the solution with respect to initial state and model parameters is derived for both linear and nonlinear systems. A brief introduction to numerical integration theory is presented.

This theory is then combined in Chapter 5 with ideas developed in Chapters 1 and 2 to develop a theory of estimation of dynamic systems. Methods and algorithms are developed for estimation of initial state, model parameters, and the state of a dynamic system at a discrete sequence of points in time. The latter result is extended by taking the limit, as the time grid goes to zero, to obtain conditions and algorithms for continuous state estimation. Finally, sequential estimation of nonlinear dynamic systems is briefly treated.

In the final chapter, methods of Chapter 5 are used to solve optimal estimation problems involving projectile trajectories and satellite photogrammetry.

The text is clearly written at a technical level and should be accessible to advanced senior undergraduate students, first-year graduate students, and practicing engineers and scientists. The author's insights and care in formulating and solving illustrative examples will greatly aid the applications-oriented reader. Presentations of none but essential mathematical concepts and the basic theory of minimization, probability, and linear algebra make the text essentially self-contained. The text is recommended to anyone with a moderate mathematical background who wants to gain access to the methods and more advanced literature on optimal estimation of dynamical systems.

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THE DYNAMICAL BEHAVIOR OF STRUCTURES - 2ND EDITION

G.B. Warburton

Pergamon Press, Maxwell House, Elmsford, NY, 1976

This delightful little book, written by a master structural dynamicist, is a complete revision, up-dated to provide information on current thinking. The book contains six major chapters plus five appendixes.

Chapter I discusses the single-degree-of-freedom system and responses due to harmonic motion, hysteretic damping, shock response, and transient response including Duhamel's integral. The shock response section is too short for such an important topic. The chapter concludes with an introduction to random processes and random vibration.

Chapter II introduces the reader to dynamics of frames (harmonic and transient analysis). The use of matrix methods in multi-degree-of-freedom systems is described, as are the normal mode method of solution and complex eigenvalue procedures. The chapter concludes with random vibration, too short a discussion, but the reviewer considers this an excellent chapter.

Beam vibration plays an important role in structural dynamics. The author leads us from simple beam theory to the more complex, with general end conditions in Chapter III. Harmonic, simple, and transient responses are described. The author packs a tremendous amount of information into a small section, including the Rayleigh–Ritz for uniform and nonuniform beams and an introduction to finite elements.

Chapter IV delves further into beam theory: the response to time-dependent boundary conditions, beam column vibration, beams in elastic foundations, shear deformation, and torsion. The chapter concludes with a discussion of the dynamic response of rigid-plastic beams.

Chapter V focuses upon vibrations of plates and shells. Most vibration texts omit these important topics. Transverse vibration of rectangular plates with simple end conditions are discussed, as are the use of Rayleigh-Ritz method and the finite element approach to in-plane vibration of plates. The author briefly discusses four- and eight-node isoparametric elements applied to plate design and then shows how they can be applied to transient response of plates. The dynamics of shells are considered, as is its matrix application.

In Chapter VI the author briefly considers fluid-structure dynamic interaction, which is emerging as an important phase of dynamics. Ground-structure dynamic interaction (important in earthquake applications) is briefly considered. Wind-induced vibration of structures is lightly touched upon. The reviewer would have liked more discussion of applications dealing with fluid structures utilizing random processes.

The appendixes include Fourier transforms, matrix properties, Lagrangian equations, and orthogonality conditions for beams. A short section on eigenvalue economizers has direct application to finite elements.

In summary, this is an excellent book considering the large number of topics that are discussed. The reviewer believes that the book could be enhanced by extending the sections on random vibrations and fluid-structure dynamic interaction and finite elements.

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BOOK REVIEWS: 1979

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SHORT COURSES

DECEMBER

SURFACE BLASTING

Dates: December 5-7, 1979
Place: Washington, D.C.
Objective: This is a field-oriented course on commercial surface blasting (quarries, open pits and construction). The course uses a variety of presentation techniques, including movies, problem solving, question and answer sessions and special "hands-on" exercises. Topics to be covered are: commercial explosives in use today; detonation methods; rock breakage; blast design; blasting economics; and blasting and the neighbors.

Contact: E.I. du Pont de Nemours & Co. (Inc.), Applied Technology Division, Room 35901, Wilmington, DE 19898 - (302) 774-6406.

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION

Dates: December 10-14, 1979
Place: Ling Electronics, Anaheim, California
Dates: February 4-8, 1980
Place: Santa Barbara, California
Dates: April 7-11, 1980
Place: Dayton, Ohio
Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis, also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos St., Santa Barbara, CA 93105 - (815) 682-7171.

MACHINERY VIBRATION ANALYSIS

Dates: December 11-13, 1979
Place: New Orleans, Louisiana
Objective: The topics to be covered during this course are: fundamentals of vibration; transducer concepts; machine protection systems; analyzing vibration to predict failures; balancing; alignment; case histories; improving your analysis capability; managing vibration data by computer; and dynamic analysis.

Contact: Bob Kiefer, Spectral Dynamics, P.O. Box 671, San Diego, CA 92112 - (714) 268-7100.

JANUARY

PROBABILISTIC AND STATISTICAL METHODS IN MECHANICAL AND STRUCTURAL DESIGN

Dates: January 7-11, 1980
Place: Tucson, Arizona
Objective: To provide practical information on engineering applications of probabilistic and statistical methods, and design under random vibration environments. Modern methods of structural and mechanical reliability analysis will be presented. Special emphasis will be given to fatigue and fracture reliability.

Contact: Dr. Paul H. Wirsching, College of Engineering, The University of Arizona, Tucson, AZ 85721 - (602) 626-3159/626-3054.

FINITE ELEMENT ANALYSIS

Dates: January 7-11, 1980
Place: Tucson, Arizona
Objective: The purpose of this course is to provide structural engineering practitioners with an understanding of the fundamental principles of finite element analysis, to describe applications of the method, and to present guidelines for the proper use of the method and interpretation of the results obtained through it. Emphasis will be placed upon the

linear analysis of frameworks, plates, shells and solids; and dynamic analysis will also be treated.

Contact: Dr. Hussein Kamel, College of Engineering, The University of Arizona, Tucson, AZ 85721 - (602) 626-1650/626-3054.

DYNAMIC ANALYSIS IN TURBOMACHINERY DESIGN

Dates: January 14-18, 1980
Place: Madison, Wisconsin
Objective: This course will be devoted to the understanding of mechanical phenomena involved in turbomachinery design, including torsional and lateral shaft vibrations and vibrations of components such as rotating fan and turbine blades and non-rotating vanes. Topics to be covered include lumped parameter analysis of rotors in rigid and flexible bearings, internal and external damping, effects of coupled transverse and angular motion; lumped parameter and normal mode analysis of blade response allowing for effects of damping, hysteresis loop characteristics, slip at dovetails and at platforms; and vibrations of stationary vanes. Some state of the art experimental techniques will be discussed.

Contact: Dr. Donald E. Baxa, Dept. of Engineering, University of Wisconsin - Extension, 432 N. Lake St., Madison, WI 53706 - (608) 262-2061.

FEBRUARY

FIXTURE DESIGN FOR VIBRATION AND SHOCK TESTING

Dates: February 11-15, 1980
Place: Santa Barbara, California
Dates: March 10-14, 1980
Place: St. Petersburg, Florida
Objective: The relative mertis of various types of shakers and shock test machines are briefly considered, with most emphasis on electromagnetic shakers. The seminar will be devoted to practical and proven simplified design and fabrication techniques. An important area to be covered is that of evaluating a fixture once it is built.

Contact: Wayne Tustin, Tustin Institute of Technology, 22 East Los Olivos St., Santa Barbara, CA 93105 - (815) 682-7171.

FINITE ELEMENTS IN BIOMECHANICS

Dates: February 18-21, 1980
Place: Tucson, Arizona
Objective: As a forum for the exchange of ideas, for the definition of the state-of-the-art, and for the presentation of new research results in biomechanics.

Contact: Professor Bruce R. Simon, Dept. of Aerospace and Mechanical Engineering, College of Engineering, The University of Arizona, Tucson, AZ 85721 - (602) 626-3752/626-3054.

BALANCING OF ROTATING MACHINERY

Dates: February 26-28, 1980
Place: Shamrock Hilton, Houston, Texas
Objective: The seminar will emphasize the practical aspects of balancing in the shop and in the field. The instrumentation, techniques, and equipment pertinent to balancing will be elaborated with case histories. Demonstrations of techniques with appropriate instrumentation and equipment are scheduled. Specific topics include: basic balancing techniques (one- and two-plane), field balancing, balancing without phase measurement, balancing machines, use of programmable calculators, balancing sensitivity, flexible rotor balancing, and effect of residual shaft bow on unbalance.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254/654-2053.

MARCH

MEASUREMENT SYSTEMS ENGINEERING

Dates: March 10-14, 1980
Place: Phoenix, Arizona

MEASUREMENT SYSTEMS DYNAMICS

Dates: March 17-21, 1980
Place: Phoenix, Arizona
Objective: Program emphasis is on how to increase

productivity, cost-effectiveness and data-validity of data acquisition groups in the field and in the laboratory. Emphasis is also on electrical measurements of mechanical and thermal quantities.

Contact: Peter K. Stein, 5602 East Monte Rosa, Phoenix, AZ 85018 - (602) 945-4603/946-7333.

MACHINERY VIBRATIONS COURSE

Dates: March 17-20, 1980
Place: Oakbrook Hyatt House, Oakbrook, IL
Objective: This course on machinery vibrations will cover physical/mathematical descriptions, calculations, modeling, measuring, and analysis. Machinery vibrations control techniques, balancing, isolation, and damping, will be discussed. Techniques for machine fault diagnosis and correction will be reviewed along with examples and case histories. Torsional vibration measurement and calculation will be covered.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254/654-2053.

BOUNDARY INTEGRAL EQUATION METHODS

Dates: March 17-22, 1980
Place: University of Arizona, Computer Center
Objective: The objective of this short course is to introduce the Boundary Integral Equation Method (BIEM) as an efficient numerical tool for the solution of various types of ground-water problems. The course is designed to provide a working knowledge of the BIEM so that the participants will be able to use and modify the existing computer programs and to develop their own programs for their specific problems.

Contact: Professor James A. Liggett or Professor Phillip L.-F. Liu, School of Civil and Environmental Engrg., Cornell University, Hollister Hall, Ithica, NY 14853 - (607) 256-3556/256-5090 respectively.

EXPLOSION HAZARDS EVALUATION

Dates: March 31-April 4, 1980
Place: Southwest Research Institute
Objective: This course covers the full spectrum of problems encountered in assessing the hazards of accidental explosions, in designing the proper containment as necessary, as well as developing techniques to reduce incidence of accidents during normal plant and transport operations. Specific topics to be covered are: fundamentals of combustion and transition to explosion; free-field explosions and their characteristics; loading from blast waves; structural response to blast and non-penetrating impact; fragmentation and missile effects; thermal effects; damage criteria; and design for blast and impact resistance.

Contact: Wilfred E. Baker, Southwest Research Institute, P.O. Drawer 28510, San Antonio, TX 78284 - (512) 684-5111, Ext. 2303.

APRIL

ACOUSTICS AND NOISE CONTROL

Dates: April 14-18, 1980
Place: The University of Tennessee Space Inst.
Objective: This is an introductory course dealing with the fundamentals of vibration and noise control. The equations governing the vibrations of continuous systems and sound propagation will be developed and certain elementary solutions derived to illustrate the basic characteristics of the wave motion. Sound propagation in the atmosphere, acoustic filters and resonators, and the attenuation of sound in rooms and ducts by acoustic treatment will be discussed. Fundamental measurement techniques and statistical parameters applicable to the description of noise will be presented.

Contact: Jules Bernard, The Univ. of Tennessee Space Institute, Tullahoma, TN 37388 - (615) 455-0631, Ext. 276.

APPLICATIONS OF TIME SERIES ANALYSIS

Dates: April 14-18, 1980
Place: Institute of Sound and Vibration Research, University of Southampton, UK
Objective: To provide a comprehensive treatment of time and frequency domain analysis methods for transient and stationary random signals summarizing essential theory and giving engineering applications.

To present theories and some applications related to non-stationary processes, system identification and response of non-linear systems to stochastic excitation. To apply the theory to well conceived practical problems utilizing the computers in the Data Analysis Centre enabling participants to experience how new methods may be related to present day industrial requirements.

Contact: Dr. Joseph K. Hammond, Institute of Sound and Vibration Research, University of Southampton, Southampton, Hampshire, England, S09 5NH - 559122, Ext. 467.

JUNE

MACHINERY VIBRATIONS SEMINAR

Dates: June 24-26, 1980

Place: Mechanical Technology, Inc.
Latham, New York

Objective: To cover the basic aspects of rotor-bearing system dynamics. The course will provide a fundamental understanding of rotating machinery vibrations; an awareness of available tools and techniques for the analysis and diagnosis of rotor vibration problems; and an appreciation of how these techniques are applied to correct vibration problems. Technical personnel who will benefit most from this course are those concerned with the rotor dynamics evaluation of motors, pumps, turbines, compressors, gearing, shafting, couplings, and similar mechanical equipment. The attendee should possess an engineering degree with some understanding of mechanics of materials and vibration theory. Appropriate job functions include machinery designers; and plant, manufacturing, or service engineers.

Contact: Mr. Paul Babson, MTI, 968 Albany-Shaker Rd., Latham, NY 12110 - (518) 785-2371.

NEWS BRIEFS

news on current and Future Shock and Vibration activities and events

1979 SAE AEROSPACE MEETING

The 1979 SAE Aerospace Meeting will be held at the Hyatt House at the Los Angeles Airport on December 3-6.

Topics to be covered are: Simulation - state of the art review; The need and prospects for multi-role transport aircraft; Advances in dynamic analysis & design; Advances in dynamic & modal analysis/testing; Options for heavy lift rotorcraft; and Options for high speed rotorcraft.

Registration fees are as follows: SAE members - no fee (membership card must be shown); Nonmember guests - $15.00 daily (will be credited toward the combination of membership initiation fee and first year's dues, when elected, if application is made within six months), and $48.00 for the entire meeting; College students - $1.00 (college ID cards must be shown).

Papers will be on sale at $1.95 each during the meeting in the SAE Publication Sales Area. Papers may also be ordered from SAE Headquarters at the following prices: Members $1.95 each and Nonmembers $2.95 each.

A tour of the Continental Airlines Maintenance Facilities will be held on Wednesday evening, December 5.

For further information or a complete program contact: Phil Columbus, SAE Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096 - (412) 776-4841.

ABSTRACT CATEGORIES

ANALYSIS AND DESIGN

Analogs and Analog Computation
Analytical Methods
Dynamic Programming
Impedance Methods
Integral Transforms
Nonlinear Analysis
Numerical Analysis
Optimization Techniques
Perturbation Methods
Stability Analysis
Statistical Methods
Variational Methods
Finite Element Modeling
Modeling
Digital Simulation
Parameter Identification
Design Information
Design Techniques
Criteria, Standards, and Specifications
Surveys and Bibliographies
Tutorial
Modal Analysis and Synthesis

COMPUTER PROGRAMS

General
Natural Frequency
Random Response
Stability
Steady State Response
Transient Response

ENVIRONMENTS

Acoustic
Periodic
Random
Seismic
Shock
General Weapon
Transportation

PHENOMENOLOGY

Composite
Damping
Elastic
Fatigue
Fluid
Inelastic
Soil
Thermoelastic
Viscoelastic

EXPERIMENTATION

Balancing
Data Reduction
Diagnostics
Equipment
Experiment Design
Facilities
Instrumentation
Procedures
Scaling and Modeling
Simulators
Specifications
Techniques
Holography

COMPONENTS

Absorbers
Shafts
Beams, Strings, Rods, Bars
Bearings
Blades
Columns
Controls
Cylinders
Ducts
Frames, Arches
Gears
Isolators
Linkages
Mechanical
Membranes, Films, and Webs
Panels
Pipes and Tubes
Plates and Shells
Rings
Springs
Structural
Tires

SYSTEMS

Absorber
Acoustic Isolation
Noise Reduction
Active Isolation
Aircraft
Artillery
Bioengineering
Bridges
Building
Cabinets
Construction
Electrical
Foundations and Earth
Helicopters
Human
Isolation
Material Handling
Mechanical
Metal Working and Forming
Off-Road Vehicles
Optical
Package
Pressure Vessels
Pumps, Turbines, Fans, Compressors
Rail
Reactors
Reciprocating Machine
Road
Rotors
Satellite
Self-Excited
Ship
Spacecraft
Structural
Transmissions
Turbomachinery
Useful Application

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, VA 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (UM), 313 N. Fir St., Ann Arbor, MI; U.S. Patents from the Commissioner of Patents, Washington, D.C. 20231. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

ABSTRACT CONTENTS

ANALYSIS AND DESIGN

ANALYTICAL METHODS

(Also see Nos. 2236, 2237)

79-2125

The Role of Observations in Stochastic Linear Dynamic Models

T. Prasad and O. Ibidapo-Obe

Solid Mechanics Div., Univ. of Waterloo, Waterloo, Ontario, Canada N2L 3G1, Appl. Math. Modeling, 3 (4), pp 263-268 (Aug 1979) 4 figs, 3 tables, 20 refs

Key Words: Mathematical models, Stochastic processes

Emphasis is placed on using realistic observations for response evaluation in stochastic linear dynamic systems. A simulation study is performed. The structural model and the ensuing computational algorithms are presented, keeping in view their relevance to numerous applied problems of life sciences and technology.

79-2126

The Effects of Internal Resonance on Impulsively Forced Non-Linear Systems with Two Degrees of Freedom

R.P. Vito and G. Cabak

School of Engrg. Science and Mechanics, Georgia Inst. of Tech., Atlanta, GA 30332, Intl. J. Nonlin. Mech., 14 (2), pp 93-99 (1979) 3 figs, 5 refs

Key Words: Internal resonance, Two degree of freedom systems

The method of multiple time scales is used to study the non-linear oscillations of impulsively forced systems under conditions of internal resonance. A partial analytical solution is obtained. The method is illustrated by an example in which the internal resonance effects are shown to be significant.

79-2127

Elastodynamics of Planar Mechanisms Using Planar Actual Finite Line Elements, Lumped Mass Systems, Matrix-Exponential Method, and the Method of "Critical-Geometry-Kineto-Elasto-Statics"

C. Bagci and S. Kalaycioglu

Tennessee Technological Univ., Cookeville, TN 38501 J. Mech. Des., Trans. ASME, 101 (3), pp 417-427 (July 1979) 32 figs, 1 table, 49 refs

Key Words: Mechanisms, Elastodynamic response

The article presents a general method for the elastodynamic analysis of planar mechanisms. It uses planar actual finite line elements and lumped mass systems to formulate the equations of motion of a mechanism. The matrix exponential method is introduced for the numerical solution of the equations of motion. Matrix displacement method of determining dynamic stresses using the generalized coordinate displacements is given. Elastodynamic analysis of a plane four-bar mechanism is performed for several cycles of kinematic motion, and the dynamic stresses are compared with those obtained by experiments.

OPTIMIZATION TECHNIQUES

(Also see No. 2277)

79-2128

Computational Techniques in Optimal State-Estimation – A Tutorial Review

W. Kortum

German Research Ctr. for Aeronautics and Astronautics (DFVLR), Inst. for Dynamics of Flight Systems, Oberpfaffenhofen, Germany 8031, J. Dyn. Syst., Meas. and Control, Trans. ASME, 101 (2), pp 99-107 (June 1979) 2 figs, 3 tables, 19 refs

Key Words: Optimization, Dynamic systems, Reviews

The objective of this tutorial presentation is to review the main computational techniques of the state-estimation problem for linearizable dynamic systems where the design is oriented toward a minimum variance (quadratic loss, gaussian) estimation error. The continuous and the discrete estimation problem are both treated.

79-2129

Mechanism Optimization via Optimality Criterion Techniques

W.A. Thornton, K.D. Willmert, and M.R. Khan
Clarkson College of Technology, Potsdam, NY 13676, J. Mech. Des., Trans. ASME, 101 (3), pp 392-397 (July 1979) 3 figs, 4 tables, 17 refs

Key Words: Mechanisms, Optimization

Presented in this paper are two new design techniques, based on optimality criteria, for selecting the cross-sectional sizes of the links within a mechanism. The objective is to minimize weight subject to stress and displacement (deformation) constraints. The mechanisms are assumed to be undergoing vibrational effects. These new optimality criterion methods are compared with a standard SUMT technique of nonlinear programming.

MODELING

79-2130

Modelling as an Aid in Measurement Technology, Part 1 (Modellbildung, ein Hilfsmittel der Messtechnik, Teil 1)

E.D. Gilles
Institut f. Systemdynamik und Regelungstechnik, Universität Stuttgart, Pfaffenwaldring 9, 7000 Stuttgart 80, West Germany, Techn. Messen-ATM, 46 (6), p 225 (June 1979) 13 figs, 16 refs
(In German)

Key Words: Mathematical models, Measurement techniques

The use of mathematical models for the calculation of certain parameters in a mechanical system which cannot be measured directly is presented.

79-2131

Interactive Modeling and Analysis of Open or Closed Loop Dynamic Systems with Redundant Actuators

R.J. Williams and A. Seireg
Pennsylvania State Univ., University Park, PA 16802, J. Mech. Des., Trans. ASME, 101 (3), pp 407-416 (July 1979) 11 figs, 39 refs

Key Words: Mathematical models

This paper deals with the development of a computer-based procedure for the modeling and analysis of large displacement dynamic systems of the open or closed loop types. The procedure facilitates the construction of the model for such systems, automatically formulates the dynamic equations and provides the solution for any given input motion. The program is capable of analyzing complex systems with redundant force actuators utilizing a linear programming optimization scheme.

CRITERIA, STANDARDS, AND SPECIFICATIONS

(See No. 2218)

SURVEYS AND BIBLIOGRAPHIES

79-2132

Recent Developments for the Nonlinear Distortion of Non-Dispersive Acoustic Waves. Part I: Planar Waves and the Basic Method

J.H. Ginsberg
School of Mech. Engrg., Purdue Univ., West Lafayette, IN 47907, Shock Vib. Dig., 11 (7), pp 3-8 (July 1979) 50 refs

Key Words: Reviews, Elastic waves

This two-part paper describes a perturbation procedure for investigating finite amplitude acoustic waves that depend on more than one spatial coordinate. The discussion focuses on wave motions that are non-dispersive in the linear approximation, in which case amplitude dispersion and self-refraction are the primary mechanisms for nonlinear distortion. Part I covers planar waves and the basic method.

79-2133

Behavior of Elastomeric Materials Under Dynamic Loads - II

E.C. Hobaica
Electric Boat Div., General Dynamics Corp., Eastern Point Rd., Groton, CT 06340, Shock Vib. Dig., 11 (7), pp 11-18 (July 1979) 7 figs, 30 refs

Key Words: Reviews, Elastomers, Periodic excitation, Testing techniques

This review describes the properties of rubber and other elastomers when they are subjected to small amplitude sinusoidal stresses. Testing methods and data on dynamic properties are given.

79-2134

Approximate Techniques for Plastic Deformation of Structures Under Impulsive Loading. II

W.E. Baker

Southwest Research Inst., P.O. Box 28510, San Antonio, TX 78284, Shock Vib. Dig., 11 (7), pp 19-24 (July 1979) 4 figs, 1 table, 30 refs

Key Words: Reviews, Testing techniques, Impact response (mechanical)

Recent work on approximate techniques for plastic deformation of structures under impulsive loading is summarized. Research-oriented methods and design-oriented methods are described. Several design-oriented methods have been utilized by structural designers.

COMPUTER PROGRAMS

GENERAL

(Also see No. 2249)

79-2135

CEL Blast Wave Propagation Code for Air Ducts

R.S. Chapler and R.H. Fashbaugh

Civil Engrg. Lab. (Navy), Port Hueneme, CA, Rept. No. CEL-TN-1543, 64 pp (Jan 1979)

AD-A066 259/3GA

Key Words: Shock wave propagation, Computer programs, Nuclear explosion effects, Ducts, Ventilation, Hardened installations

Refinement of a CEL hydrodynamic code for prediction of air blast propagation in variable area ventilation ducts was completed. Code solutions are one-dimensional and achieved using a refined finite-difference pseudo-viscosity method in a Lagrange formulation for solution of either classical nuclear blast waves or general time variant pressure waves. Solutions for a single constant area duct with the effects of viscosity at the wall are included. An example case is presented with a description of the single duct geometry, the applied nuclear blast parameters, and the code input parameters, including their magnitudes and their sources.

ENVIRONMENTS

ACOUSTIC

(Also see No. 2132)

79-2136

A New Type Flap Valve for Generating Sonic Booms in a Pyramidal Horn

J.J. Gottlieb, W. Czerwinski, N.N. Wahba, and R.E. Gnoyke

Inst. for Aerospace Studies, Toronto Univ., Ontario, Canada, Rept. No. UTIAS-208; CN-ISSN-0082-5255, 78 pp (Oct 1978)

N79-23755

Key Words: Sonic boom, Simulation

The design, operation and performance of a radically new type of sonic-boom generating flap-valve are described with emphasis on the ancillary cam, clutch, flywheel and electric motor system, and the air reservoir which is much larger than those used previously. An updated and greatly extended analysis describes the time varying reservoir conditions (e.g., pressure) and mass-flow rate of air through the flap valve, as well as the wave motion or characteristics of the traveling N-wave in the pyramidal concrete horn of traveling-wave sonic-boom simulation facility.

79-2137

A Study of Scattering, Production, and Stimulated Emission of Sound by Vortex Flows

J.E. Yates

Aeronautical Research Associates of Princeton, Inc., NJ, Rept. No. NASA-CR-3139; ARAP-363, 62 pp (May 1979)

N79-23756

Key Words: Fluid-induced excitation, Vortex noise, Acoustic scattering, Sound generation

The basic theory of aeroacoustics of homentropic fluid media is applied to the problems of sound scattering, production, and stimulated emission. A general theory of scattering from low speed three-dimensional vortex flows is presented. Specific results are given for the horseshoe vortex and vortex ring. The noise of an elementary corotating vortex pair in various flows is calculated.

79-2138
Potential Energy Effects on the Sound Speed in Liquids
B. Hartmann
Polymer Physics Group, Naval Surface Weapons Ctr., White Oak, Silver Spring, MD 20910, J. Acoust. Soc. Amer., 65 (6), pp 1392-1396 (June 1979) 1 fig, 22 refs

Key Words: Sound propagation, Liquids

Sound speed in liquids is calculated in terms of Mie potential parameters with the assumption that the intermolecular potential energy is the dominant factor. Using this simple model, it is shown that Beyer's parameter of nonlinearity, Rao's exponent, and the Gruneisen parameter are all simply related to each other.

79-2139
Correlation Function Determination for Inhomogeneities Scattering an Acoustic Wave
J. Lewandowski
Dept. of Physical Acoustics, Inst. of Fundamental Technological Research, Polish Academy of Sciences, Warsaw, Poland, Arch. Acoust., 3 (4), pp 283-292 (1978) 7 refs

Key Words: Wave propagation, Wave diffraction, Elastic waves

A random inhomogeneous isotropic medium filling a domain immersed in an infinitely extended homogeneous isotropic medium is considered. The formulae describing the scalar potential of the scattered field are deduced for small and large distances from the domain of the heterogeneous material. The fluctuations of density and wave propagation velocity are treated as random variables of the space coordinates. The correlation function is calculated from the appropriate farfield solution and expressed in terms of a scalar potential for the angular distribution of the scattered wave. This general method is adapted for a nonviscous random emulsion and the correlation function is expressed in terms of the intensity angular distribution of the scattered wave.

79-2140
Theoretical Study of Finite Amplitude Standing Waves in Rectangular Cavities with Perturbed Boundaries
M. Aydin
Naval Postgraduate School, Monterey, CA, 61 pp (Dec 1978)
AD-A066 356/7GA

Key Words: Sound waves, Resonant cavities

The effects of various geometrical boundary perturbations on finite-amplitude acoustical standing waves in a rectangular, rigid-walled cavity are investigated using non-linear theory. The standing waves that exist in an ideal cavity must be corrected when the boundaries are irregular. Three specific examples (stepped, linear and wedged perturbations) are worked out to demonstrate the corrections (in first order) near degeneracies for small perturbations. Those specific examples are compared to the experiments.

79-2141
Virtual Modes and Mode Amplitudes Near Cutoff
C.T. Tindle
Applied Research Labs., The Univ. of Texas at Austin, TX 78712, J. Acoust. Soc. Amer., 65 (6), pp 1423-1428 (June 1979) 5 figs, 8 refs

Key Words: Underwater sound, Normal modes

For a Pekeris model the contribution of the continuous mode integral is analyzed in terms of virtual modes with particular attention to cases with a discrete mode just below or just above cutoff. There is a steady change of amplitude as a virtual mode changes into a discrete mode. The mode amplitudes decay with range and analytic approximations valid in most practical situations are obtained.

79-2142
A Method of Predicting Noise Equivalent Level Value in Urban Structure
R. Makarewicz and G. Kerber
Adam Mickiewicz Univ., Arch. Acoust., 3 (4), pp 231-248 (1978) 7 figs, 27 refs

Key Words: Urban noise, Noise prediction

The paper presents a method of predicting the noise equivalent level value in urban structure. The paper presents a solution of the problem of determination of the minimum number of the measurements of the parameter necessary to determine the noise equivalent level value with a preset accuracy.

79-2143
An Analysis of Contoured Crystal Resonators Operating in Overtones of Coupled Thickness Shear and Thickness Twist
H.F. Tiersten and R.C. Smythe
Dept. of Mech. Engrg., Aeronautical Engrg. and Mechanics, Rensselaer Polytechnic Inst., Troy, NY 12181, J. Acoust. Soc. Amer., 65 (6), pp 1455-1460 (June 1979) 3 figs, 3 tables, 7 refs

Key Words: Quartz resonators, Variable cross section

A previous treatment of overtone modes in trapped energy resonators is extended to the case of plates with slowly varying thickness. The resulting single scalar equation is applied in the analysis of plano-convex contoured quartz crystal resonators, and a lumped parameter representation of the admittance, which is valid in the vicinity of a resonance, is obtained. The influence of piezoelectric stiffening, electrode mass loading, and electrical shorting is included in the analysis.

PERIODIC

(Also see No. 2133)

79-2144
An Application of Newton's Diagram in the Periodic Solution of Quasiharmonic Oscillator, and the Stability of Such Solution (Une Application de Diagramme de Newton a la Recherche Des Solutions Periodiques D'un Oscillateur Quasiharmonique et L'etude de la Stabilite de Ces Solutions)
V. Carpent, J. Hubin, and G. Khmelevskaja-Plotnikova
Facultes Universitaires Notre-Dame de la Paix, Namur, 61 rue de Bruxelles, Belgique, Intl. J. Nonlin. Mech., 14 (2), pp 67-80 (1979) 1 fig, 4 tables, 9 refs (In French)

Key Words: Periodic response

Periodic solutions of autonomous quasiharmonic systems are studied in the resonant case if the branching equation has multiple roots. Newton's diagram is used to find all the real solutions of this equation. The stability of the periodic solutions is also considered.

RANDOM

79-2145
Mathematical Model of the Stick-Slip Phenomenon
J. Korycki
Working Liquids Group, Materials and Tech. Dept., Aviation Inst., Warsaw, Poland, Wear, 55 (2), pp 261-263 (Aug 1979) 1 fig, 6 refs

Key Words: Stick-slip response, Mathematical models

A mathematical model of the stick-slip phenomenon is presented which is related to the characteristic changes of the friction forces as a function of the slip speed. The model leads to simple differential equations without the necessity of using distribution equations. It can be utilized in a simple way to describe actual friction nodes.

SEISMIC

79-2146
Study of Selected Events in Pamirs in a Seismic Discrimination Context
P.A. Sobel, D.H. von Seggern, E.I. Sweetser, and D.W. Rivers
Seismic Data Analysis Center, Teledyne Geotech, Alexandria, VA, Rept. No. SDAC-TR-77-3, 74 pp (Oct 10, 1977)
AD-A066 325/2GA

Key Words: Seismic detection, Earthquakes

Eleven earthquakes with low reported M sub s for their m sub b from the Northern Pamirs were examined in a seismic discrimination context. Seismograms from ALPA, LASA, NORSAR, the HGLP and the WWSSN stations were studied for source mechanism, M sub s-m sub b, corner frequency, pP, complexity, and spectral ratio. All the Pamir events can be identified as earthquakes when their characteristics are compared to those of Kazakh explosions.

79-2147

Extraction of Seismic Waveforms

A.C. Strauss

Equipment Group, Texas Instruments, Inc., Dallas, TX, Rept. No. TI-ALEX(01)-TR-78-02, 75 pp (Sept 29, 1978)

AD-A066 711/3GA

Key Words: Seismic detection, Seismic waves

This report considers the effects on detectability and measurability resulting from attempts to extract seismic waveforms by application of cascaded processors and polarization filters.

79-2148

Application of Ringdal's Method to Unbiased Measurement of the Ms-mb Relationship

A.C. Strauss

Equipment Group, Texas Instruments, Inc., Dallas, TX, Rept. No. TI-ALEX(01)-TR-78-03, 50 pp (Aug 31, 1978)

AD-A066 712/1GA

Key Words: Seismic detection, Seismic waves

Ringdal's maximum likelihood method of removing magnitude bias was tested by removing the apparent bias of surface wave magnitude estimates. Bias removal was demonstrated by comparing maximum likelihood estimates of M sub s obtained by a single sensor to those obtained by an array at the Alaskan Long Period Array (ALPA) site. Since the beamformed array has a lower detection threshold than the single-sensor reference site, it can serve as the standard by which to judge whether positive magnitude bias has been removed from the reference site surface wave magnitude estimates.

79-2149

Short-Period Noise Envelope Statistics: A Basis for Envelope Detector Design

R. Unger

Equipment Group, Texas Instruments, Inc., Dallas, TX, Rept. No. TI-ALEX(01)-TR-78-05, 78 pp (Sept 26, 1978)

AD-A066 713/9GA

Key Words: Seismic detection, Seismic waves

This report focuses on the use of certain detection statistics, in particular the instantaneous amplitude or envelope, and the instantaneous power, in the design of a controlled false alarm rate detector. To achieve false alarm rate control, the detection statistic must be stationary, but need not be Gaussian. Parameters of a Gaussian process can be conveniently transformed into a stationary, normalized detection statistic.

79-2150

Seismic Analysis of Internal Equipment and Components in Structures

J.L. Sackman and J.M. Kelly

Dept. of Civil Engrg., Univ. of California, Berkeley, CA, *Engrg. Struc.*, 1 (4), pp 179-180 (July 1979) 7 figs, 20 refs

Key Words: Equipment response, Seismic response

In this paper, a rational approach to the design of lightly damped relatively light equipment in structures subjected to seismic loading or other forms of ground motion is presented. The analysis is carried out in the context of a model that consists of an N-degree of freedom structure to which is attached a single-degree-of-freedom component. An analytical method is developed whereby a simple estimate can be obtained of the maximum dynamic response of light equipment attached to a structure subjected to ground motion.

SHOCK

(Also see Nos. 2134, 2135, 2272)

79-2151

The Structure of Shock Layers in Elastic-Plastic Media: Micro-Plastic Regime

R.W. Lardner and S. Ramakesavan

Dept. of Mathematics, Simon Fraser Univ., Burnaby, British Columbia V5A 1S6, Canada, Intl. J. Nonlin. Mech., 14 (2), pp 81-92 (1979) 5 figs, 15 refs

Key Words: Shock waves, Shock wave propagation, Elasto-plastic properties

The Granato-Lücke theory of internal friction is used as the basis of a model of shock-wave formation and propagation in elasto-plastic solids below the general yield point. The structure of shock layers in such a model is shown to be in general asymmetric and, at sufficiently large jumps in strain, to exhibit oscillations in the strain at its trailing edge.

79-2152

Extending Finite Element Methodology for a Class of Impact Problems

A.T. Change

Dept. of Mech. Engrg., Stevens Inst. of Tech., Hoboken, NJ, Rept. No. ARO-15522, 34 pp (Feb 1979) AD-A066 044/9GA

Key Words: Finite element technique, Impact response (mechanical)

This research has concentrated on a class of impact problems whose angle of impact is so shallow that the target impact disturbance might be considered as a surface wave problem. The theoretical background for the pressure distribution developed during impact is given in the last chapter.

79-2153

Some Notes on the Dynamic Properties of Unsaturated Concrete

S.T. Wu

EBASCO Services, Inc., 2 Rector St., New York, NY 10006, Nucl. Engr. Des., 53 (1), pp 97-103 (June 1979) 9 figs, 1 table, 22 refs

Key Words: Concretes, Dynamic response

A simplified computation model is presented at the microscopic level to predict the dynamic behaviors of unsaturated concrete. The dynamic response to the stress waves are formulated and described. With certain assumptions, the transient mass flow from the hindered absorbed layer to the capillary pores can be evaluated in the transient state.

PHENOMENOLOGY

DAMPING

(Also see No. 2182)

79-2154

Elastomer Mounted Rotors – An Alternative for Smoother Running Turbomachinery

J.A. Tecza, M.S. Darlow, S.W. Jones, A.J. Smalley, and R.E. Cunningham

Mechanical Technology Inc., Latham, NY, ASME Paper No. 79-GT-149

Key Words: Elastomeric dampers, Rotors (machine elements), Turbomachinery, Unbalanced mass response

This paper describes the design of elastomeric bearing supports for a rotor built to simulate the power turbine of an advanced gas turbine engine which traverses two bending critical speeds. The elastomer dampers are constructed to minimize rotor dynamic response at the critical speeds. Results are presented of unbalance response tests performed with two different elastomer materials.

79-2155

The Response of a Single Degree of Freedom System with Quadratic Damping to Step and Impulse Inputs

G. Jacazio and B. Piombo

Istituto di Meccanica Applicata alle Macchine, Politecnico, Torino, Italy, Mech. Res. Comm., 6 (3), pp 121-127 (1979) 4 figs, 3 refs

Key Words: Single degree of freedom systems, Quadratic damping

Single degree of freedom systems with quadratic damping are often encountered in mechanical systems; particularly in hydraulic systems where damping is often obtained by forcing oil to flow through a small orifice.

79-2156

A Design Point Correlation for Losses Due to Part-Span Dampers on Transonic Rotors

W.B. Roberts
Dept. of Aerospace and Mech. Engrg., Univ. of Notre Dame, Notre Dame, IN, J. Engr. Power, Trans. ASME, 101 (3), pp 415-421 (June 1979) 11 figs, 20 refs

Key Words: Dampers, Fan blades

The design-point losses caused by part-span dampers are correlated for 21 transonic axial-flow fan rotors that have tip speeds varying from 350 to 488 meters per second and design pressure ratios of 1.5 to 2.0. The additional loss attributable to the damper and the total region along the blade height influenced are correlated with selected aerodynamic and geometric parameters.

79-2157
Oil Squeeze Film Dampers for Reducing Vibration of Aircraft Gas Turbine Engines
T. Miyachi, S. Hoshiya, Y. Sofue, M. Matsuki, and T. Torisaki
National Aerospace Lab., Tokyo, Japan, ASME Paper No. 79-GT-133

Key Words: *Vibration dampers,* **Squeeze film dampers, Aircraft engines, Gas turbine engines**

Theoretical analysis and experiments are carried out on cylindrical oil squeeze film dampers. The finite element method (FEM) is applied for calculating pressure distribution in the dampers with end seals and oil grooves. Measurements of the viscous damping coefficient of several dampers are conducted and compared with theoretical values. The effects of the dampers on the vibrational characteristics of engines are reviewed through theoretical analysis and experiments on an engine model. Then, the effects of squeeze film dampers on an actual engine are evaluated for design information.

FATIGUE
(Also see No. 2184)

79-2158
The Effect of Frequency and Environment on the Fatigue-Crack Growth Behaviour of ASTM A533 Grade B Class 1 Weldment Material
C.J. Poon and D.W. Hoeppner
Univ. of Toronto, Toronto, Canada M5S 1A4, Intl. J. Fatigue, 1 (3), pp 141-152 (July 1979) 23 figs, 13 refs

Key Words: Fatigue (materials), Crack propagation

The effects of frequency and distilled water environment on the fatigue-crack growth characteristics of ASTM A533 Grade B Class 1 weldment material is studied with major emphasis placed on the crack growth along the weld center-*line as well as along the heat affected zone* (HAZ). A *single* deterministic fatigue-crack growth model based on the Four Parameter Weibull Survivorship Function is used.

79-2159
Environmental Dynamic Fatigue Crack Propagation in Nylon 66
H.A. ElHakeem and L.E. Culver
The National Inst. for Standards, Cairo, Egypt, Intl. J. Fatigue, 1 (3), pp 133-140 (July 1979) 9 figs, 1 table, 21 refs

Key Words: Fatigue (materials), Crack propagation

***Standard samples* of nylon 66 *are pre-treated* in either air, water, or dilute sulphuric acid and then notched and examined for fatigue crack propagation in the various environments. Tensile dynamic fatigue tests under constant sinusoidal load amplitudes are carried out at different frequencies.**

79-2160
Gust Severity Effects on Fatigue Crack Propagation in Aluminum Alloy Sheet Materials
R.J.H. Wanhill
National Aerospace Lab., NLR, Amsterdam, The Netherlands, Intl. J. Fatigue, 1 (3), pp 118-123 (July 1979) 10 figs, 16 refs

Key Words: Fatigue (materials), Crack propagation

Flight simulation fatigue tests are carried out on specimens of two aluminum alloys to investigate the effect of differing gust load experiences on fatigue crack propagation in 7075-T6 and the effect of gust load alleviation on 2024-T3. Two gust spectra were used: the Fokker F-27 spectrum for 7075-T6; and the reference spectrum TWIST for 2024-T3.

EXPERIMENTATION

BALANCING

79-2161
High Speed Rotor Balancing
W.D. Pilkey
Dept. of Mech. and Aerospace Engrg., Univ. of Virginia, Charlottesville, VA, Rept. No. UVA/525-088/MAE78/102, ARO-15080.7-E, 14 pp (Dec 1978) AD-A067 221/2GA

Key Words: Balancing techniques, Rotors (machine elements), Shafts (machine elements), Flexible rotors

This report summarizes the accomplishments of the final year of a study exploring new methods for balancing, analyzing, and designing flexible rotating shafts. A technique for identifying rotor bearing parameters is proposed. Then a quadratic programming formulation is presented for influence coefficient balancing with constraints. Finally, a method is developed for determining the optimal axial location of balancing planes.

79-2162
Synchronous Unbalance Response of an Overhung Rotor with Disk Skew
D.J. Salamone and E.J. Gunter
Allis-Chalmers Corp., Milwaukee, WI, ASME Paper No. 79-GT-135

Key Words: Balancing techniques, Rotors (machine elements)

This paper deals with the influence of disk skew on the synchronous unbalance response of flexible rotors in damped bearings. A simple overhung rotor is treated to illustrate the effects of various combinations of unbalance and disk skew on the amplitude and phase angle response at the disk and bearings.

79-2163
Four Run Balancing Without Phase
P.O.L. Carlson
Electronic Dynamic Balancing Co., Hillside, IL, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 117-122, 7 figs

Key Words: Balancing techniques

The paper details the single plane balancing of a disc, flywheel or bladed fan such as a cooling tower fan. Other wider parts can be balanced at the center of gravity to accomplish a single plane balance.

79-2164
An Introduction to a Unified Approach to Flexible Rotor Balancing
A.G. Parkinson, M.S. Darlow, A.J. Smalley, and R.H. Badgley
Univ. College of London, UK, ASME Paper No. 79-GT-161

Key Words: Balancing techniques, Flexible rotors, Rotors (machine elements)

Existing methods for the balancing of flexible rotors are discussed and a unified approach for such balancing is presented. A program for testing the method is also described.

79-2165
Laser Balancing Demonstration on a High-Speed Flexible Rotor
R.S. DeMuth, R.A. Rio, and D.P. Fleming
Mechanical Technology Inc., Latham, NY, ASME Paper No. 79-GT-56

Key Words: Balancing techniques, Lasers, Flexible rotors, Rotors (machine elements)

This paper describes a flexible rotor system used for two-plane laser balancing and an experimental demonstration of the laser material removal method for balancing. A laboratory test rotor was modified to accept balancing corrections using a laser metal removal method while the rotor is at operating speed. The laser setup hardware required to balance the rotor using two correction planes is described.

79-2166
Five-Plane Laser Balancing System for a Flexible Rotor
R.S. DeMuth
Mechanical Technology Inc., 968 Albany-Shaker Rd., Latham, NY 12110, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 123-128, 9 figs, 2 refs

Key Words: Balancing techniques, Lasers, Flexible rotors

This paper describes the system for a five-plane laser balancing and experimental demonstration of the laser material removal method for balancing. A laboratory supercritical test rotor was modified to accept balancing corrections using a laser metal removal method while the rotor is at operating speed. The laser hardware required to balance the rotor using five correction planes is described. The optical table, laser module and laser controller were assembled and calibrated for material removal rates.

79-2167
TF30 Engine Trim Balancing and Vibration Diagnostic System
R.A. Rio, J. Rutledge, and F. Fanuele
Diagnostic Systems Section, Mechanical Technology Inc., 968 Albany-Shaker Rd., Latham, NY 12110, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 139-145, 3 figs, 1 table, 1 ref

Key Words: Balancing techniques, Diagnostic techniques, Aircraft engines

The Trim Balancing and Diagnostic System, installed in four TF30 engine test cells at the Oklahoma City Air Logistics Center (OC-ALC), is described. This project demonstrates the practical application of combining minicomputer technology with extensive rotor dynamics expertise to provide the Air Force with a system which solves many of the previously mentioned problems.

DIAGNOSTICS

(Also see Nos. 2167, 2189)

79-2168
Machinery Vibration Monitoring and Analysis Seminar and Meeting Proceedings
Sponsored by Vibration Institute, Apr 1979, New Orleans, LA, Avail: Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514

Key Words: Machinery vibration, Vibration monitoring, Diagnostic techniques

Twenty five papers presented at the Machinery Vibration Monitoring and Analysis Seminar and Meeting feature lectures on techniques for data analysis and problem identification and correction, and methods for evaluating and reporting data. The seminar was directed to individuals involved in the design, experimental testing, development and procurement of reciprocating and rotating machinery. Vibration problems likely to occur during the development and commissioning of new equipment are described. An annotated bibliography listing 198 items is also included. (Individual papers are also abstracted in this issue of the DIGEST).

79-2169
Random Test Generation for Fault Detection and Diagnosis
D.K. Goel
Ph.D. Thesis, Syracuse Univ., NY, 260 pp (1978)
UM 7908534

Key Words: Diagnostic techniques

A method of test generation is developed which aims at: eliminating the golden unit (a random test generation scheme in which the outputs of the golden unit and the circuit under test are compared); minimizing the length of the test sequence; reducing the complexity of deriving the tests; minimizing the chances of making a wrong decision; and minimizing the information required for reaching a decision about the state of the circuit. The testing procedure developed is analogous to the statistical hypothesis testing problem. Tests are derived for four different kinds of faults. The effectiveness of the tests is studied by randomly injecting faults into a circuit. A new testing procedure called the sequential probabilistic testing procedure is developed for the purpose of fault diagnosis. An algorithm is presented for computing the optimal sequential testing procedure for locating a fault.

79-2170
The Practical Vibration Primer
C. Jackson
Gulf Publishing Co., Houston, TX, 1979, 114 pp, Avail: Vibration Institute, 101 W. 55th St., Clarendon Hills, IL 60514

Key Words: Diagnostic techniques, Machinery vibration, Books

The Practical Vibration Primer provides a working knowledge of the fundamentals required to evaluate malfunctions caused by excessive vibration. It begins with the basics of vibratory motion, and expands to cover the application of measurement and correction techniques. In addition to discussing motion-displacement, velocity, and acceleration of vibrating systems, with practical examples and illustrations to enhance understanding, the book describes various types of sensors used to measure vibration. Also provided are guidelines for selecting the proper machinery and structure vibration sensor. Other topics include logarithmic scaling, filters, phase and basic balancing (machine balancing techniques are illustrated with example problems), instrumentation, severity, thrust bearings, alignment, and information on how to avoid the common mistake of confusing strobe vibration analysis with probe vibration analysis.

79-2171

Computer Managed Vibration Monitoring and Analysis of Plant Machinery

B. Buckley and J. Chavez

DYMAC Div. of Spectral Dynamics, San Diego, CA, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 183-189, 5 figs

Key Words: Diagnostic techniques, Turbomachinery

This paper describes some manufacturer's results in combining current computer and vibration instrumentation technology. This new system is dedicated to monitoring and analysis of plant turbomachinery (and auxiliary equipment) health and performance.

79-2172

The Right Way to Overhaul Turbomachinery

J.D. Houghton

Shell Oil Co., Deer Park, TX, Hydrocarbon Processing, 58 (6), pp 129-136 (June 1979) 3 figs, 2 tables, 4 refs

Key Words: Diagnostic techniques, Turbomachinery

How to plan, execute and document turbomachinery overhauls are described based on data gathered on approximately 30 machines. Specific examples of what can go wrong and corrective action are also included.

79-2173

Investigating Steady State Vibrations in Large Engines and Reciprocating Compressors

T.J. Finneran

Ingersoll-Rand Co., Painted Post, NY, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 155-161, 10 figs

Key Words: Diagnostic techniques, Reciprocating engines, Periodic response

This paper is primarily concerned with the investigation of vibrations associated with large engines and reciprocating compressors, but is also applicable to other machinery. Its intent is to familiarize users of this equipment with some vibration principles, the major sources of excitation and the reasons why excessive vibrations may occur. It finally outlines investigatory procedures on vibration problems when they arise. First, the steps to be followed by observations; second, the steps to be followed using instruments. It concludes with some examples where these principles have been used.

79-2174

Dynamic Analysis of a 7500 HP Induction Motor

J.E. Corley

Rotating Equipment, Arabian American Oil Co., Dhahran, Saudi Arabia, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 37-41, 6 figs

Key Words: Diagnostic techniques, Induction motors

This paper describes the diagnosis and analysis of two large four pole induction motors which are used in a crude oil loading system. The paper describes the techniques used to analyze the resonance and the experimental testing using an impedance analysis system to obtain the system stiffnesses necessary to model the system. The paper also presents the analysis of the recommended solution using an elliptical bearing to detune the horizontal resonance.

79-2175

An Analysis Procedure for the Validation of On-Site Performance Measurements of Gas Turbines

R.K. Agrawal, B.D. MacIsaac, and H.I.H. Saravanamutto

Carleton Univ., Ottawa, Canada, J. Engr. Power, Trans. ASME, 101 (3), pp 405-414 (June 1979) 18 figs, 9 refs

Key Words: Diagnostic techniques, Gas turbine engines

In order to ensure accuracy and credibility of an engine health monitoring system, it is vital that the measurements used in the analysis process be accurate. An analysis procedure is developed to verify the accuracy of daily measurements taken from industrial gas turbines in the gas pipeline industry. The procedure is extended to use the measurements to develop an engine health monitoring system for this class of equipment which is based solely on existing instrumentation.

79-2176

Measurement Techniques for Preventing Fan Vibration Failures

P.K. Baade

Dynamics Research Div., Carrier Corp., Syracuse, NY 13221, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 27-36, 10 figs, 7 refs

Key Words: Fans, Diagnostic techniques, Critical speeds

This paper is concerned with the development of a practical measurement technique for predicting the critical speeds of propeller fans used in typical heating, refrigeration and air conditioning units. The paper reviews a typical fan failure history and describes tests conducted to diagnose the cause of the failure, as well as two different test methods which are candidates for an ASHRAE standard aimed at preventing such failures. Areas requiring further work are outlined.

79-2177

Automating Signature Analysis for Predicting Machinery Failures

B.M. Rickert

Mechanical Technology Inc., 968 Albany-Shaker Rd., Latham, NY 12110, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 191-197

Key Words: Diagnostic techniques, Machinery, Vibration signatures, Signatures, Computer aided techniques

A system for automating the techniques of signature analysis, which reduces the cost of performing a detailed signature analysis by a factor of ten, is described.

79-2178

The Shock Pulse Method for Determining the Condition of Anti-Friction Bearings

K. Barthel

Testing Machines, Inc., Amityville, NY, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 199-204, 10 figs

Key Words: Diagnostic techniques, Shock pulse method, Antifriction bearings, Bearings

The Shock Pulse Method, which is based on monitoring the mechanical impacts caused by bearing damage and operating condition problems, is described. It allows a bearing's condition to be tested over its entire life.

79-2179

A Comparison of Vibration Measurement Techniques for Monitoring and Analysis

R.L. Fox

IRD Mechanalysis, Inc., Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 73-82, 15 figs

Key Words: Diagnostic techniques, Vibration measurement, Measuring instruments, Rotor-bearing systems

This paper discusses the three basic approaches in vibration measurement in terms of transducer selection and practical limitations. An evaluation of each measurement approach is made with consideration given to various rotor/bearing configurations as well as relative response to various specific machinery malfunctions and associated vibration characteristics. Recommendations and conclusions are supported with comparative spectrum analysis data of each measurement approach obtained on a variety of machinery installations.

79-2180

Identification of Gear Defects by Vibration Analysis

J.I. Taylor

Gardinier, Inc., Tampa, FL, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 93-105, 23 figs

Key Words: Diagnostic techniques, Vibration signatures, Gears

This paper describes procedures for identifying gear defects and/or problems. Analysis of vibration velocity signals in the time and frequency domains was utilized. The specific gear that causes the mesh problems can be identified by analyzing gear mesh frequencies.

79-2181

Detection of Valve Leakage in Reciprocating Compressors by Demodulated Resonance Analysis

D.L. St. John

Shell Oil Co., Wood River, IL, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 177-182, 11 figs

Key Words: Diagnostic techniques, Valves, Compressors, Demodulated resonance analysis

This paper is a discussion of the relevant factors involved in successfully developing a technique to improve reciprocating compressor reliability and maintenance cost through the early detection of defective valves by demodulated resonance analysis.

79-2182

An Effective Discriminant for Evaluating the Quality of Viscous Dampers Applied to EMD 20-645E3 Locomotive Engines

H. Hershkowitz

Applications Engrg., Scientific-Atlanta, Inc., Randolph, NJ, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 147-153, 6 figs, 4 tables, 7 refs

Key Words: Diagnostic techniques, Vibration dampers, Viscous damping, Torsional vibration

In situations where many different measured parameters describe the functional performance of a system, the methods of Multivariate Discriminatory Analysis allow the accept-reject criteria to be readily determined. This paper illustrates one such technique and demonstrates a means of estimating the quality of viscous torsional vibration dampers, where three measured parameters are associated with the determination.

79-2183

Statistical Techniques for Automating the Detection of Anomalous Performance in Rotating Machinery

K.R. Piety and T.E. Magette

Oak Ridge National Lab., Oak Ridge, TN 37830, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 163-176, 9 figs, 4 tables, 23 refs

Key Words: Diagnostic techniques, Statistical analysis, Automated testing, Rotating structures

A methodology for monitoring industrial rotating equipment which would upgrade ongoing programs and yet still be practical for implementation is investigated. An improved anomaly recognition methodology is formulated and implemented on a minicomputer system. The effectiveness of the monitoring system is evaluated in laboratory tests on a small rotor assembly, using vibrational signals from both displacement probes and accelerometers.

79-2184

Simultaneous Monitoring of Acoustic Emission and Ultrasonic Attenuation During Fatigue of 7075 Aluminum

J.C. Duke, Jr. and R.E. Green, Jr.

College of Engrg., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24001, Intl. J. Fatigue, 1 (3), pp 125-132 (July 1979) 9 figs, 40 refs

Key Words: Fatigue (materials), Diagnostic techniques, Acoustic emission

A thorough review of the previous work employing either technique (ultrasonic attenuation monitoring or acoustic emission monitoring) for the examination of aluminium during fatigue is presented.

EQUIPMENT

(Also see No. 2150)

79-2185

Transient Analysis of Equipment-Structure Interaction at High Frequencies

J.L. Sackman and J.M. Kelly

Weidlinger Associates, Menlo Park, CA, Rept. No. R-7828, DNA-4675F, 66 pp (May 1978)

AD-A066 607/3GA

Key Words: Equipment response, Transient excitation

An analytical method is developed which yields a simple estimate of the maximum dynamic response of light equipment attached to a structure subjected to ground motions. The natural frequency of the equipment, modeled as a single-degree-of-freedom system, is considered to be close, or equal, to one of the natural frequencies of the N-degree-of-freedom structure. The approach is based on the transient analysis of lightly damped, tuned or detuned equipment-structure systems in which the mass of the equipment is small in comparison with that of the structure.

FACILITIES

79-2186

Measurements of Low-Velocity Flow Noise on Pressure and Pressure Gradient Hydrophones

R.A. Finger, L.A. Abbagnaro, and B.B. Bauer

CBS Technology Center, Stamford, CT 06905, J. Acoust. Soc. Amer., 65 (6), pp 1407-1412 (June 1979) 7 figs, 9 refs

Key Words: Test facilities, Noise measurement, Fluid-induced excitation

A circular flow tank facility is developed which features extremely low acoustic and vibration ambient conditions. This facility is described, operating procedures associated with its use are presented, and limitations in the measurement procedures are mentioned. The flow facility is used to measure the noise output of pressure and pressure gradient hydrophones during actual flow conditions and results of these tests are presented and discussed.

INSTRUMENTATION

(Also see No. 2179)

79-2187

Vibration Measurement - An Introduction to Piezoceramic Accelerometers and Associated Instrumentation - Part 2

D. Purdy

Noise Control Vib. Isolation, 10 (5), pp 178-181 (May 1979) 11 figs, 5 refs

Key Words: Vibration measurement, Measuring instrumentation, Accelerometers

In part 2 of this article, continued from the April 1979 issue, the conditioning of signals from piezoceramic accelerometers is discussed.

79-2188

Concepts and Transducers Used in Measuring Dynamic Mass

R.R. Bouche

Bouche Labs., Sun Valley, CA, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 11-17, 7 figs, 7 refs

Key Words: Electrodynamic shakers, Vibration measurement, Measurement techniques, Measuring instruments

The general requirements for accurate dynamic mass measurements include using a small electrodynamic shaker together with an accelerometer and force gage having high sensitivities. The mechanical impedance or mobility can be computed from the measured dynamic mass simply by using the relationship between the velocity and acceleration for sinusoidal vibration motion. There are many important applications for the simplest form of dynamic mass measurements. These include measuring the dynamic mass at the driving point and the transfer dynamic mass while applying a single rectilinear force.

79-2189

A Review of Machinery Analysis Instrumentation

J.S. Mitchell

Turbomachinery Consultant, San Juan Capistrano,

CA, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 1-9, 6 figs

Key Words: Machinery, Vibration analyzers, Measuring instruments

Vibration transducers, signal conditioning and some of the factors which must be considered in deciding which measurement to make are discussed. This paper is a condensation of three chapters in a comprehensive book on machinery analysis which will provide the reader with a good general basis for machinery analysis.

SCALING AND MODELING

79-2190
Use of Scaled Plastic Models in Mobility Studies
R.L. Bannister
Westinghouse Electric Corp., Lester, PA, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., New Orleans, LA, pp 19-23, 3 tables, 40 refs

Key Words: Scaling

This paper reviews the techniques that are used to design, construct and test scaled plastic models. Scaling laws, material characteristics, mobility analyses, experimental procedures, and test instrumentation are covered.

TECHNIQUES
(See Nos. 2130, 2188)

COMPONENTS

SHAFTS
(Also see No. 2161)

79-2191
Shaft and Casing Motion of Large, Single Shaft, Industrial Gas Turbines
R.C. Eisenmann
North American Region, Bently Nevada Corp., Houston, TX, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 83-91, 10 figs

Key Words: Shafts, Gas turbines, Lateral vibration, Test equipment and instrumentation, Vibration tests

This paper addresses the shaft and casing vibration response characteristics of large, single shaft, industrial gas turbines. A contemporary suite of vibration transducers consisting of proximity displacement probes, velocity seismoprobes, and piezoelectric accelerometers are considered. The individual transducers are discussed, and the mechanical characteristics of gas turbines are reviewed. Finally, two specific machinery examples are presented to illustrate the various measurements, and data reduction techniques.

BEAMS, STRINGS, RODS, BARS

79-2192
Wave Motion in Micropolar Elastic Bars with Rectangular Cross Section
R.Y. Vasudeva and R.K. Bhaskara
Dept. of Appl. Mathematics, Andhra Univ., Waltair, India, Intl. J. Engr. Sci., 17 (8), pp 965-971 (1979) 9 refs

Key Words: Bears, Rectangular bars, Wave propagation, Frequency equation, Normal modes

Effect of couple stresses on the propagation of elastic waves in an infinite bar of rectangular cross section is studied in the framework of Eringen's micropolar theory of elasticity. The crosswise superposition technique is used to obtain the general solution and the frequency equation for longitudinal modes of vibration of the bar.

79-2193
The Modelling of Net and Cloth Dynamics
C.M. Leech
Dept. of Mech. Engrg., The Univ. of Manchester Inst. of Science and Tech., Manchester, UK M60 1QD, J. Franklin Inst., 307 (6), pp 361-378 (1979) 6 figs, 17 refs

Key Words: Mathematical models, Grids (beam grids)

The dynamic modeling of dense nets, cloths and gridworks is approached through Hamilton's principle and Fourier series. The technique is examined in consequence of natural frequencies, travelling waves and wave propagation. The model is checked with previous results. The approach is extendible to laminates and to reinforcements.

79-2194

Vibration Properties of Curved Thin-Walled Beams

A. Rutenberg

Faculty of Civil Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, ASCE J. Struc. Div., 105 (ST7), pp 1445-1455 (July 1979) 3 figs, 2 tables, 12 refs

Key Words: Beams, Curved beams, Bridges, Natural frequencies

A simple procedure is proposed to evaluate the out-of-plane vibration frequencies for a class of horizontally curved beams. The method is illustrated by a numerical example: a fixed-fixed curved highway with open cross-section.

79-2195

On the Rectilinear Motion of an Inextensible String

M. Kuipers

Dept. of Mathematics, Univ. of Groningen, Groningen, The Netherlands, J. Engr. Math., 13 (3), pp 249-256 (July 1979) 5 figs, 3 refs

Key Words: Strings, Chains, Normal modes

In this paper the rectilinear motion of a string or chain with no bending stiffness, which is arranged in a straight line and bent double is investigated. Two mechanisms, one of which is dissipative and the other is not are examined. The results of the calculations are compared with analogous computations in the literature.

79-2196

Inertial Effects of Masses Moving on Cables

J.L. Kanning

Ph.D. Thesis, Purdue Univ., 163 pp (1978)
UM 7914913

Key Words: Cables (ropes), Moving loads, Inertial forces

The effect of inertia on the motion of masses traveling on taut cables is investigated. An approximate analytical solution is presented. A numerical approach fully accounting for kinematical coupling effects is also presented. Finally, the numerical solution, developed for a moving point mass, is shown to be adaptable to systems with continuous moving masses, and the dynamic stability of tubular cantilevers conveying fluid is briefly investigated. The numerical results are compared with theoretical and experimental results from Gregory and Paidoussis.

79-2197

Seismic Support: Speedy Determination of Frequency

A.K. Kar

Ebasco Services, Inc., New York, NY, ASCE J. Struc. Div., 105 (ST7), pp 1289-1306 (July 1979) 12 figs, 9 refs

Key Words: Cables (ropes), Seismic response, Nuclear power plants

Approximate formulas, based on the stiffness of the SDOF models, are presented to determine the natural frequencies very quickly and reliably. The formulas have the added advantage of demonstrating the contribution of different members to the frequency of a frame. The use of the formulas, presented in the paper, can considerably simplify the dynamic analysis of seismic supports for electrical cables and HVAC ducts in nuclear power plant and other structures.

79-2198

Cable Spring Constants for Guyed Tower Analysis

R.A. Skop

Appl. Mechanics Branch, Ocean Tech. Div., U.S. Naval Research Lab., Washington, D.C., ASCE J. Struc. Div., 105 (ST7), pp 1307-1318 (July 1979) 5 figs, 17 refs

Key Words: Cables (ropes), Towers, Guyed structures

In this paper new formulas are developed for calculating guy cable preloads and spring constants. The formulas are evolved for arbitrarily loaded guys containing any number of discrete masses and having arbitrary constitutive relations. The calculations of guy preloads and spring constants from these formulas are demonstrated by numerical examples.

BEARINGS

(Also see No. 2178)

79-2199

Dynamically Loaded Bearings Operating with Non-Newtonian Lubricant Films

Z.S. Safar
Mech. Engrg. Dept., Univ. of California, Berkeley, CA 94720, Wear, 55 (2), pp 295-304 (Aug 1979) 7 figs, 12 refs

Key Words: Bearings, Lubrication

The behavior of a laminar non-Newtonian film (power law) is studied for dynamically loaded bearings. An expression for the modified Reynolds equation in obtained for the non-Newtonian fluid film. The load-carrying capacity is obtained for various values of the viscometric exponent of the power law model.

79-2200

Predicting Wear in Misaligned Rolling Contact

P.A. Engel
IBM Corp., Endicott, NY, Mach. Des., 51 (17), pp 128-132 (July 26, 1979)

Key Words: Bearings, Wear, Alignment, Antifriction bearings

A new procedure for the determination of wear of rolling machinery components is described. The method shows how to determine the critical misalignment angle, given the contact geometry and elastic properties of two rolling surfaces. Then, from the critical misalignment angle, the maximum wear depth that can be expected at the contact area edge of the two surfaces is determined.

79-2201

Analysis of Fitted Partial Arc and Tilting-Pad Journal Bearings

M.N. Abdul-Wahed, J. Frene, and D. Nicolas
Institut National des Sciences Appliquees de Lyon, 69621 Villeurbanne, France, ASLE Trans., 22 (3), pp 257-266 (July 1979) 21 figs, 10 refs

Key Words: Bearings, Tilting pad bearings

As a step towards tilting fitted-pad bearing, calculated steady-state and dynamic characteristics are given for the finite-length fitted partial arc bearing for different values of bearing angle. Steady-state and dynamic characteristics are then given for a tilting-pad bearing with the load between pads. Results are compared with the similar clearance type bearing.

79-2202

Geometry Effects in Tilting-Pad Journal Bearings

G.J. Jones and F.A. Martin
The Glacier Metal Co., Ltd., Wembley, Middlesex, UK, ASLE Trans., 22 (3), pp 227-244 (July 1979) 14 figs, 2 tables, 12 refs

Key Words: Bearings, Tilting pad bearings, Geometric effects

A theoretical study is undertaken to show the influence of bearing geometry on the steady-state and dynamic behavior of tilting-pad journal bearings. The computer model used takes into account a different viscosity on each pad, turbulence in the oil film and pad inertia. The geometric changes considered include the pad clearance and the bearing clearance, the length/diameter ratio, the number of pads, and the orientation of the bearing with respect to the load direction. The major operating characteristics examined are oil film thickness, pad temperature, power loss, and oil film stiffness and damping.

79-2203

Analytical and Experimental Determination of Surface Finish Effects on the EHD Performance of Ball Bearings

T.E. Russell and J.C. Clark
General Electric Co., Cincinnati, OH 45215, ASLE Trans., 22 (3), pp 286-292 (July 1979) 8 figs, 4 tables, 15 refs

Key Words: Bearings, Ball bearings, Fatigue tests, Surface roughness

An analytical and experimental analysis is conducted to determine the effects of surface finish on the elastohydrodynamic performance of a group of 168-mm bore diameter, gas turbine engine, main shaft ball bearings found to have discrepant outer raceway surface finishes.

79-2204

Dynamics of Rolling-Element Bearings. Part I: Cylindrical Roller Bearing Analysis

P.K. Gupta

Mechanical Technology Inc., 968 Albany-Shaker Rd., Latham, NY 12110, J. Lubric. Tech., Trans. ASME, 101 (3), pp 293-304 (July 1979) 8 figs, 14 refs

Key Words: Bearings, Roller bearings

An analytical formulation for the roller motion in a cylindrical roller bearing is presented in terms of the classical differential equations of motion. Roller-race interaction is analyzed in detail and the resulting normal force and moment vectors are determined. Elastohydrodynamic traction models are considered in determining the roller-race tractive forces and moments. Formulation for the roller end and race flange interaction during skewing of the roller is also considered.

79-2205

Dynamics of Rolling-Element Bearings. Part II: Cylindrical Roller Bearing Results

P.K. Gupta

Mechanical Technology Inc., 968 Albany-Shaker Rd., Latham, NY 12110, J. Lubric. Tech., Trans. ASME, 101 (3), pp 305-311 (July 1979) 16 figs, 8 refs

Key Words: Bearings, Roller bearings

Cylindrical roller bearing performance simulations are expressed in terms of the general motion of the bearing elements as derived by integrating the differential equations of motion. Roller skew as induced by relative race misalignment is simulated. The influence of geometrical parameters, such as roller/cage or race/cage clearance and radial preload, on the roller and cage motion is also investigated.

79-2206

Dynamics of Rolling-Element Bearings. Part III: Ball Bearing Analysis

P.K. Gupta

Mechanical Technology Inc., 968 Albany-Shaker Rd., Latham, NY 12110, J. Lubric. Tech., Trans. ASME, 101 (3), pp 312-318 (July 1979) 5 figs, 19 refs

Key Words: Bearings, Ball bearings

An analytical formulation for the generalized ball, cage, and race motion in a ball bearing is presented in terms of the classical differential equations of motion. Ball-race interaction is analyzed in detail and the resulting force and moment vectors are determined. The ball-cage and race-cage interactions are considered to be either hydrodynamic or metallic and a critical film thickness defines the transition between the two regimes. Simplified treatments for the drag and churning losses are also included to complete a rigorous analytical development for the real-time simulation of the dynamic performance of ball bearings.

79-2207

Dynamics of Rolling-Element Bearings. Part IV: Ball Bearing Results

P.K. Gupta

Mechanical Technology Inc., 968 Albany-Shaker Rd., Latham, NY 12110, J. Lubric. Tech., Trans. ASME, 101 (3), pp 319-326 (July 1979) 24 figs, 9 refs

Key Words: Bearings, Ball bearings, Alignment

Dynamic simulations of the performance of a ball bearing are presented in terms of the general motion as obtained by integrating the differential equations of motion of the various bearing elements.

79-2208

Elastohydrodynamic Contact Between Two Rollers Under Conditions of Unsteady Motion

S. Pytko and K. Wierzcholski

Dept. of Machines, Technical Univ. AGH, Krakow, Poland, Wear, 55 (2), pp 245-260 (Aug 1979) 2 figs, 2 tables, 3 refs

Key Words: Bearings, Rolling contact bearings, Rolling friction, Contact vibration, Elastohydrodynamic properties, Lubrication

An analysis of the elastohydrodynamic (EHD) contact between two rotating rollers in unsteady motion when one roller rolls around the other is presented.

BLADES

79-2209

Optimization of Propeller Skew Distribution to Minimize the Vibratory Forces and Moments Acting at the Propeller Hub

60

M.G. Parsons and J.E. Greenblatt
Dept. of Naval Architecture and Marine Engrg., Michigan Univ., Ann Arbor, MI, Rept. No. UM/NAME-206, MA-RD-940-79023, 66 pp (Dec 1978) PB-293 934/6GA

Key Words: Blades, Propeller blades, Marine propellers, Skew plates, Optimum design, Computer programs

The propeller skew design problem is formulated as an optimization problem to minimize a weighted, linear combination of the six vibratory forces and moments acting at the propeller hub. The SKEWOPT propeller skew optimization program is described. This interactive program was developed to perform the propeller skew optimization in a routine design setting. The vibratory forces and moments are evaluated using either a two-dimensional, sinusoidal gust theory or a three-dimensional, unsteady, lifting-line theory.

COLUMNS

79-2210

Inelastic Response of Reinforced Concrete Columns Subjected to Two-Dimensional Earthquake Motion

M.I.H. Suharwardy
Ph.D. Thesis, Univ. of Illinois at Urbana-Champaign, 225 pp (1979)
UM 7915433

Key Words: Columns, Reinforced concrete, Earthquake response

This study was undertaken to determine the effects of two-dimensional earthquake motion on reinforced concrete (R/C) columns. An analytical model to represent the shear-deflection-axial load relationship of R/C columns is developed from stress-strain relations of steel and concrete. The analytical model compares favorably with experimental results for both uniaxial and biaxial loading conditions. The analytical model predicts significant changes in the strength, energy absorption capacity and accumulated damage responses of the column under biaxial deformations as compared to the corresponding responses under uniaxial deformations.

79-2211

Parametric Response of a Metallic Column at Elevated Temperature

G.J. Wang
Dept. of Mechanics and Materials Science, Rutgers Univ., New Brunswick, NJ 08903, Intl. J. Nonlin. Mech., 14 (2), pp 123-132 (1979) 5 figs, 13 refs

Key Words: Parametric resonance, Columns, Thermal excitation, Self-excited vibrations

The parametric response of a metallic column at elevated temperature is investigated, taking into account its nonlinear viscous characteristics. An asymptotic method for the determination of the region of self-excitation and the amplitudes and phase angles for both stationary and non-stationary responses is outlined briefly.

CONTROLS

(Also see No. 2181)

79-2212

Some Connections Between Modern and Classical Control Concepts

A.E. Bryson, Jr.
Paul Pigott Professor of Engrg., Stanford Univ., Stanford, CA 94305, J. Dyn. Syst., Meas. and Control, Trans. ASME, 101 (2), pp 91-98 (June 1979) 15 figs, 13 refs

Key Words: Control equipment, Structural synthesis

This is a tutorial paper that discusses the synthesis of optimum constant-gain feedback controllers for stationary linear systems. A fourth order example is used throughout the paper to help clarify the concepts.

79-2213

Experience with Experimental Applications of Multivariable Computer Control

D.E. Seborg and D.G. Fisher
Dept. of Chemical and Nuclear Engrg., Univ. of California, Santa Barbara, CA 93106, J. Dyn. Syst., Meas. and Control, Trans. ASME, 101 (2), pp 108-116 (June 1979) 12 figs, 38 refs

Key Words: Control equipment, Computer aided techniques

This paper summarizes experience gained over the past ten years in applying multivariable control techniques to a pilot

scale, double effect evaporator at the University of Alberta. It is possible to make meaningful comparisons between conventional control strategies and modern multivariable techniques including: optimal control, eigenvalue assignment, state estimation, adaptive control, frequency domain methods, time delay compensation, disturbance localization and model reference identification. The paper concludes with a discussion of the implications of this research for industrial application.

DUCTS
(Also see No. 2135)

79-2214
A Statistical Theory for Sound Radiation and Reflection from a Duct
Y.C. Cho
Joint Inst. for Advancement of Flight Sciences, The George Washington Univ., NASA Langley Research Ctr., Hampton, VA 23665, J. Acoust. Soc. Amer., 65 (6), pp 1373-1379 (June 1979) 8 figs, 13 refs

Key Words: Ducts, Sound waves, Sound propagation, Sound reflection, Statistical analysis

A new analytical method is introduced for the study of the sound radiation and reflection from the open end of a duct. The sound is thought of as an aggregation of the quasi-particles-phonons. The motion of the latter is described in terms of the statistical distribution, which is derived from the classical wave theory. The results are in good agreement with the solutions obtained using the Wiener-Hopf technique.

FRAMES, ARCHES

79-2215
Reinforced Concrete Ductile Frames Under Earthquake Loadings with Stiffness Degradation
D. Soleimani
Ph.D. Thesis, Univ. of California, Berkeley, CA, 533 pp (1978)
UM 7914772

Key Words: Frames, Reinforced concrete, Earthquake response

An extensive experimental and analytical research program for the inelastic response evaluation of ductile moment-resisting reinforced concrete multistory frame structures under strong earthquake motions is described. A twenty-story, four-bay strong column-weak beam reinforced concrete ductile frame, representing a typical office building, is designed in accordance with the seismic resistant 1970 UBC and 1971 ACI Code provisions. The influence of column axial deformations, flexural stiffness variations, and shear deformations on the static elastic analysis of the frame is examined.

GEARS
(Also see No. 2180)

79-2216
Dynamic Behavior of Planetary Gear (4th Report, Influence of the Transmitted Tooth Load on the Dynamic Increment Load)
T. Hidaka, Y. Terauchi, and K. Ishioka
Yamaguchi Univ., Tokiwadai, Ube, Japan, Bull. JSME, 22 (168), pp 877-884 (June 1979) 14 figs, 7 refs

Key Words: Gears

The influence of the transmitted tooth load on the dynamic increment load and others about a single-stage Stoeckicht planetary gear (Type 2K-H) constructed with spur gears is studied.

79-2217
Why Gears Explode
R.J. Drago and F.W. Brown
Boeing Vertol Co., Philadelphia, PA, Power Transm. Des., 21 (7), pp 77-80 (July 1979) 6 figs

Key Words: Gears, Resonant frequencies

Several experimental techniques for determining resonant frequencies and mode shapes of gearing components are described.

79-2218
Low-Cycle Fatigue and Ultimate Strength Related to Gear Design
W.L. Moore

The Boeing Co., Seattle, WA, J. Mech. Des., Trans. ASME, 101 (3), pp 373-379 (July 1979) 11 figs, 1 table, 16 refs

Key Words: Gears, Standards, Fatigue life

This paper describes the development of a method for assessing the ultimate tensile and limit load strength values required by MIL-A-8860(ASG) for aircraft actuator gear teeth, and the subsequent effect of a few very-high-load cycles with regard to bending and surface fatigue life. Background and application data are provided for gear teeth under relatively common load conditions that are not included in AGMA standards.

LINKAGES

79-2219

Painless Analysis of Four-Bar Linkages

L.O. Barton

E.I. du Pont de Nemours & Co., Wilmington, DE, Mach. Des., 51 (17), pp 124-127 (July 26, 1979)

Key Words: Four bar mechanisms, Linkages

A technique is presented which simplifies the calculation of stresses, loads, vibration, and noise in a four-bar linkage by using elementary algebra and trigonometry to calculate link velocity and acceleration.

MECHANICAL

79-2220

Reaction Forces in Elastomeric Couplings

H. Schwerdlin

Lovejoy Inc., Downers Grove, IL, Mach. Des., 51 (16), pp 76-79 (July 12, 1979)

Key Words: Couplings, Flexible couplings, Testing techniques

Tests for the determination of reaction forces in flexible couplings caused by misalignment, speed and torque, and their effect on bearings, shafts, and other drive components are described.

79-2221

Application of the Infinitesimal Operators of Translation and Rotation (No. 1. The Lineage of Dynamic Equations)

N. Oshima

Faculty of Engrg., Univ. of Tokyo, Hongo, Bunkyo-ku, Tokyo, Japan, Bull. JSME, 22 (168), pp 809-814 (June 1979) 4 figs, 2 refs

Key Words: Mechanical elements

Various mechanical quantities and conservation equations of dynamics can be arranged by means of appropriate infinitesimal operators. In the dynamics of point mass systems, the infinitesimal operators of translation and rotation yield various dynamical quantities from the energy form. Dynamics of a rigid body is considered from the view-point of infinitesimal operators.

79-2222

Coupling Response

H. Schwerdlin

Lovejoy Inc., Downers Grove, IL, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 57-62, 11 figs

Key Words: Couplings, Mechanical systems, Alignment

Reaction forces exerted on a mechanical system by the misalignment of couplings, torque, and speed were measured under controlled conditions. The system tested consisted of a four cylinder gasoline engine and disc brake dynamometer connected by a variety of flexible couplings.

MEMBRANES, FILMS, AND WEBS

79-2223

Forced Vibration of a Prestressed Rectangular Membrane: Near Resonance Response

V.O.S. Olunloyo and K. Hutter

Univ. of Lagos, Lagos, Nigeria, Acta Mech., 32 (1-3), pp 63-77 (1979) 2 figs, 5 refs

Key Words: Membranes (structural members), Rectangular membranes, Forced vibration, Resonant response, Viscous damping, Flexural stiffness, Anisotropy

Using singular perturbation the near resonance behavior of anisotropically prestressed thick rectangular membranes is analyzed to determine the effects of viscous damping, bending rigidity, prestress anisotropy and aspect ratio.

79-2224
Experiments on a Aerofoil at High Angle of Incidence in Longitudinal Oscillations

C. Maresca, D. Favier, and J. Rebont
Institut de Mecanique des Fluides, Laboratoire Associe no. 3 du C.N.R.S., Marseille, J. Fluid Mech., 92 (4), pp 671-690 (June 27, 1979) 18 figs, 1 table, 12 refs

Key Words: Airfoils, Aerodynamic loads, Longitudinal response

Details of flow visualization, aerodynamic forces and pitching moment, static pressure and skin friction measurements are carried out on a symmetrical *aerofoil* at fixed angle of incidence in longitudinal oscillations parallel to the uniform airstream of a wind-tunnel.

PANELS

79-2225
Effects of Environment, Damping and Shear Deformations on Flutter of Laminated Composite Panels

S.N. Chatterjee and S.V. Kulkarni
Materials Sciences Corp., Blue Bell Office Campus, Blue Bell, PA 19422, Intl. J. Solids Struc., 15 (6), pp 479-491 (1979) 8 figs, 2 tables, 34 refs

Key Words: Panels, Composite structures, Plates, Flutter, Damping effects, Transverse shear deformation effects

Flutter type instability of laminated fiber composite panels is studied based on piston theory aerodynamics and a laminated plate theory which includes the effects of shear deformations. Structural damping is considered in terms of frequency-dependent complex moduli of constituents. Stiffness of the laminae and the laminates are obtained by the use of well known elastic solutions and the dynamic elastic-viscoelastic correspondence principle. A modal method of solution is employed for obtaining flutter boundaries of panels which are constrained to deform in a state of plane deformation, i.e., cylindrical bending. Numerical results are reported for some Graphite/Epoxy laminates which are representative of laminated panels used in aircraft structures. Use is made of the shift hypothesis and shift factors of the epoxy matrix to study effects of environmental factors like temperature and moisture content.

PIPES AND TUBES

79-2226
Research on Wave Phenomena in Hydraulic Lines (5th Report, Coupled Vibration in Bending and Branching Lines)

S. Washio, T. Konishi, and T. Sonoda
Kyoto Univ., Sakyo-ku, Kyoto, Japan, Bull. JSME, 22 (168), pp 833-840 (June 1979) 18 figs, 2 refs

Key Words: Piping systems, Lateral vibration, Hydraulic equipment, Coupled response

The roles of the lateral oscillation of a pipe in the coupled vibrations of pipes with oil in hydraulic circuits are studied. The vibrations are theoretically analyzed. Solid viscosity is introduced into the dynamics of a pipe wall to explain the damping of pipe oscillations. The pipe oscillation in the lateral direction is mathematically represented by several equations of bending vibration of a beam.

79-2227
Dynamic Stability of a Liquid Carrying Pipe

A. Tylikowski
Inst. of Machine Design Fundamentals, Warsaw Technical Univ., Poland, Mech. Res. Comm., 6 (3), pp 141-146 (1979) 9 refs

Key Words: Pipes (tubes), Fluid-filled containers, Elastic foundations, Fluid-induced excitation

The stability of fluid carrying straight pipe laying on an elastic foundation is studied. Destabilizing effects of liquid motion as well as stochastic component of an axial force acting on the pipe are taken into consideration. The direct Liapunov-Movchan method is used to derive the sufficient stochastic stability conditions. Flexible hose with constant axial force and the liquid conveying pipe without elastic foundation are analyzed.

PLATES AND SHELLS

79-2228

Flutter of a Plate-Like Member in Horizontal Fluctuating Flow

E. Simiu and R.H. Scanlan
National Engrg. Lab., National Bureau of Standards, Washington, D.C., Engrg. Struc., 1 (4), pp 207-210 (July 1979) 2 tables

Key Words: Flutter, Plates, Aerodynamic loads, Bridges

An investigation of the aerodynamic stability of a thin plate in horizontally fluctuating flow is considered in the solution of the problem of suspended-span bridge flutter.

79-2229

Fluid Force on a Plate Moving Up-and-Down with a Finite Amplitude in the Still Fluid

H. Ueno and E. Kishioka
Faculty of Engrg., Kanazawa Univ., Kanazawa, Japan, Bull. JSME, 22 (168), pp 825-832 (June 1979) 17 figs, 3 refs

Key Words: Plates, Fluid-induced excitation

To investigate the fluid force acting on a body oscillating with a finite amplitude in a fluid extending to the infinite space, a brief theory is presented based on the virtual mass of the fluid taking into account the phase difference between the motion of the body and that of the virtual mass.

79-2230

Experiments on Viscoplastic Response of Circular Plates to Impulsive Loading

S.R. Bodner and P.S. Symonds
Div. of Engrg., Brown Univ., Providence, RI 02912, J. Mech. Phys. Solids, 27 (2), pp 91-113 (Apr 1979) 21 figs, 2 tables, 13 refs

Key Words: Plates, Circular plates, Impact response (mechanical), Viscoplastic properties

Tests are described of circular plates of mild steel and commercially pure titanium loaded impulsively by means of explosive sheet. Three loading geometries are used, with magnitudes such that final deflections in the range from one to about seven plate thicknesses are produced. Clamping against radial as well as transverse deflections at the edge is provided. Parameters describing this behavior are obtained from stress-strain tests at low to intermediate rates together with published data for high strain rates. The measured final deflections and response times are compared with predictions of the mode approximation technique as extended to large deflections of viscoplastic structures.

79-2231

Finite Viscoplastic Deflections of an Impulsively Loaded Plate by the Mode Approximation Technique

P.S. Symonds and C.T. Chon
Div. of Engrg., Brown Univ., Providence, RI 02912, J. Mech. Phys. Solids, 27 (2), pp 115-133 (Apr 1979) 5 figs, 22 refs

Key Words: Plates, Impact response (mechanical), Mode approximation technique, Viscoplastic properties

The application of the mode approximation technique to a fully clamped circular plate is described. Mode solutions for finite deflections are obtained from a sequence of instantaneous modes. Master solutions for chosen initial velocity amplitudes are constructed in nondimensional form. These depend weakly on a parameter of viscoplastic material behavior and size of structure, and so can be applied to a variety of loadings and structures. Finding each instantaneous mode shape and acceleration constitutes an eigenproblem, solved by finite elements with iterations. Comparisons with recent tests on steel and titanium plates are discussed in some detail.

79-2232

The Effect of Mass Loading on a Stiffening Rib

B.L. Woolley
Naval Ocean Systems Center, San Diego, CA, Rept. No. NOSC/TR-286, 29 pp (Sept 1, 1978)
AD-A066 614/9GA

Key Words: Acoustic scattering, Plates, Ribs (supports), Stiffening

In the scattering of an acoustic wave incident upon a rib-reinforced plate, the effect of the rib can be characterized by a pair of impedances. One of these impedances is associated with the longitudinal vibrations of the rib, and the

other impedance is associated with the flexural vibrations of the rib. This report calculates the impedances and the effect of mass loading on these impedances. The calculations are done for a thick or Timoshenko-Mindlin rib which is fluid loaded with the rib immersed either in water or air.

79-2233

Flow and Heat Transfer Due to Small Torsional Oscillations of a Disk About a Constant Mean

V.P. Sharma

Dept. of Mathematics, Indian Inst. of Tech., Kharagpur, India, Acta Mech., 32 (1-3), pp 19-34 (1979) 3 figs, 7 refs

Key Words: Disks, Torsional vibration

The paper deals with the study of flow and heat transfer in a viscous fluid from a disk performing small rotating oscillations about a constant mean. Separate solutions for low and high frequency ranges are developed.

79-2234

Natural Frequencies of Thin-Walled Isotropic, Circular-Cylindrical Shells

Engrg. Sciences Data Unit, London, UK, Rept. No. ESDU-78004; ISBN-0-85679-226-8, 46 pp (1978) N79-21415

Key Words: Cylindrical shells, Natural frequencies, Flexural vibrations, Torsional vibration, Chimneys, Wind-induced excitation

Graphical and tabulated data for the estimation of the lower natural frequencies of thin-walled unstiffened shells are discussed. Natural frequencies of initially unstressed shells for both flexural and torsional vibration are considered. For each combination of these mode numbers there are three natural frequencies in which the vibrating motion is either primarily radial, axial, or circumferential. Natural frequencies of shells subjected to uniform static loads are considered, and shell modal density data are given. Response calculations of shells under wide band excitation, when using statistical energy analysis methods are studied. The limitations of data presented, and some guidance on the calculation of stiffened shell natural frequencies is given. Applications include estimation of the response of shells subject to high intensity acoustic loading and estimation of natural frequencies of chimneys subject to wind loads.

79-2235

The Seismic Response of a Column-Supported Cooling Tower

C.S. Gran

Ph.D. Thesis, Purdue Univ., 142 pp (1978) UM 7914901

Key Words: Cooling towers, Shells, Seismic response

Hyperboloidal reinforced-concrete shells are modeled using orthotropic quadrilateral flat plate finite elements. The supporting columns and top ring beam are modeled by beam finite elements. Natural frequencies and corresponding mode shapes are found for several different tower configurations. Results for fixed-base shells are in close agreement with those determined using alternate methods of analysis. A cooling tower in the 1200 MW Fossil Fuel Steam Generating Power Plant at Paradise, Kentucky (Tennessee Valley Authority) is studied.

STRUCTURAL

79-2236

The Method of Quasimodal Form Solutions for the Dynamic Response of Rigid-Plastic Structures

U. Lepik

Tartu State Univ., Tartu, Estonian S.S.R., USSR, Mech. Res. Comm., 6 (3), pp 135-140 (1979) 1 fig, 1 table, 4 refs

Key Words: Dynamic response, Structural members

A technique for the analysis of a rigid-plastic thin-walled structure subjected to high dynamic loads, causing plastic hinges, is presented.

79-2237

Accelerated Convergence of Dynamic Flexibility in Series Form

Y.T. Leung

Dept. of Civil Engrg, Univ. of Hong Kong, Hong Kong, Engrg. Struc., 1 (4), pp 203-206 (July 1979) 2 figs, 8 refs

Key Words: Dynamic structural analysis, Natural frequencies, Beams, Plates

In a natural vibration analysis of a structural system, the conventional dynamic flexibility (receptance) matrix in series forms is re-examined. Examples involving beams and plates are given. The method is suitable for dynamic substructure analysis.

SEALS

79-2238

Aeroelastic Instability in F100 Labyrinth Air Seals

D.A. Lewis, C.E. Platt, and E.B. Smith

Pratt & Whitney Aircraft Group, West Palm Beach, FL, J. Aircraft, 16 (7), pp 484-490 (July 1979) 10 figs, 12 refs

Key Words: Seals (stoppers), Stability analysis

The aeroelastic instability in F100 labyrinth air seals is investigated.

79-2239

Stiffness of Straight and Tapered Annular Gas Path Seals

D.P. Fleming

NASA Lewis Research Ctr., Cleveland, OH 44135, J. Lubric. Tech., Trans. ASME, 101 (3), pp 349-355 (July 1979) 7 figs, 13 refs

Key Words: Seals (stoppers)

Radial stiffness of annular (ring-type) gas path seals is calculated for both constant-clearance designs and tapered designs for which the inlet clearance is larger than the outlet clearance.

79-2240

Hydrodynamic Effects in a Misaligned Radial Face Seal

I. Etsion

Dept. of Mech. Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, J. Lubric. Tech., Trans. ASME, 101 (3), pp 283-292 (July 1979) 6 figs, 23 refs

Key Words: Seals (stoppers), Alignment, Hydrodynamic excitation

Hydrodynamic effects in a flat seal having an angular misalignment are analyzed, taking into account the radial variation in seal clearance. An analytical solution for axial force, restoring moment, and transverse moment is presented that covers the whole range from zero to full angular misalignment. Both low pressure seals with cavitating flow and high pressure seals with full fluid film are considered.

SYSTEMS

NOISE REDUCTION

79-2241

Impulse Wave Diffraction by Rigid Wedges and Plates

J.H. Bremhorst

Naval Postgraduate School, Monterey, CA, 114 pp (Dec 1978)

AD-A066 476/3GA

Key Words: Noise barriers, Wedges, Plates, Acoustic diffraction, Acoustic absorption

The problem of diffraction of acoustic signals by rigid barriers is studied empirically. Backward and forward diffraction from a 90 degree wedge and a thin plate are analyzed. Attempts to measure the diffracted energy in the illuminated region over the apex of the barrier, when direct and reflected signals coexist with diffracted, are discussed. Factors influencing the choice of the barriers physical dimensions and composition are listed, as are the problems surrounding the selection of an ideal sound source and receiver.

79-2242

Practical Applications of Outdoor Noise Control Barriers

G.C. Tocci and W.H. Pickett

Cavanaugh Tocci Associates, Natick, MA, S/V, Sound Vib., 13 (6), pp 10-16 (1979) 17 figs, 10 refs

Key Words: Noise barriers

An overview of noise barrier attenuation estimation procedures is presented for both general noise barrier problems

and in forms which incorporate simplifying approximations for implementation in specific noise barrier problems. Estimation procedures for assessing the effect of wind and scattering of sound by trees are also described. Typical applications of outdoor noise barriers are discussed as well.

ACTIVE ISOLATION

79-2243

Design and Development of a Motion Compensator for the RSRA Main Rotor Control

P. Jeffrey and R. Huber

Sikorsky Aircraft, Stratford, CT, In: NASA Johnson Space Ctr., The 13th Aerospace Mech. Symp, pp 15-25 (1979)

N79-22541

Key Words: Active isolation, Helicopter rotors

The RSRA, an experimental helicopter, is equipped with an active isolation system that allows the transmission to move relative to the fuselage. The purpose of the motion compensator is to prevent these motions from introducing unwanted signals to the main rotor control. A motion compensator concept is developed that has six-degree-of-freedom capability. The mechanism is implemented on RSRA and its performance verified by ground and flight tests.

AIRCRAFT

79-2244

Aeroservoelastic Encounters

L.R. Felt, L.J. Huttsell, T.E. Noll, and D.E. Cooley

Air Force Flight Dynamics Lab., Wright-Patterson AFB, OH, J. Aircraft, 16 (7), pp 477-483 (July 1979)

13 figs, 23 refs

Key Words: Flight vehicles

Recent Air Force experiences that emphasize the need for aeroservoelastic considerations on a variety of research, development, prototype, and production aircraft are presented in this paper. Typical analysis and test techniques available to predict and prevent adverse aeroservoelastic effects are presented. The results of two in-house aeroservoelastic analyses are presented.

79-2245

Wing Store Active Flutter Suppression – Correlation of Analyses and Wind-Tunnel Data

T.E. Noll and L.J. Huttsell

Air Force Flight Dynamics Lab., Wright-Patterson AFB, OH, J. Aircraft, 16 (7), pp 491-497 (July 1979)

14 figs, 8 refs

Key Words: Aircraft wings, Wing stores, Flutter, Vibration control

The results of an analytical effort to study the behavior of an active flutter suppression wind-tunnel model are presented and compared with available test data. For this application, the model was aerodynamically represented by subsonic doublet lattice theory and stability was evaluated using modified Nyquist criteria.

79-2246

Physical and Subjective Studies of Aircraft Interior Noise and Vibration

D.G. Stephens and J.D. Leatherwood

NASA Langley Research Ctr., Hampton, VA, Rept. No. NASA-TM-80084, 16 pp (Apr 1979)

N79-23754

Key Words: Aircraft noise, Interior noise, Interior vibration, Helicopter noise

Measurements to define and quantify the interior noise and vibration stimuli of aircraft are reviewed as well as field and simulation studies to determine the subjective response to such stimuli, and theoretical and experimental studies to predict and control the interior environment. In addition, ride quality criteria/standards for noise, vibration, and combinations of these stimuli are discussed in relation to the helicopter cabin environment. Data on passenger response are presented to illustrate the effects of interior noise and vibration on speech intelligibility and comfort of crew and passengers.

BRIDGES

(Also see No. 2228)

79-2247

Fatigue Tests of Full-Size-Prestressed Girders

B.G. Rabbat, P.H. Kaar, H.G. Russell, and R.N. Bruce, Jr.

Construction Technology Labs., Portland Cement Assn., Skokie, IL, Rept. No. FHWA/LA-78-206(P), 148 pp (June 1978)
PB-294 291/0GA

Key Words: Bridges, Girders, Fatigue tests

An experimental investigation was carried out to determine the effect of repetitive loading on the behavior and strength of girders with draped and blanketed strands. Controlled variables in the test program were load level, development length, and use of ties to confine the concrete in the stress transfer region of the blanketed strands.

BUILDING

(Also see No. 2261)

79-2248

Earthquake Analysis of Belted High-Rise Building Structures

A. Rutenberg

Faculty of Civil Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, Engrg. Struc., 1 (4), pp 191-196 (July 1979) 9 figs, 1 table, 6 refs

Key Words: Multistory buildings, Earthquake response, Seismic response, Modal analysis

A modal analysis procedure is presented for the seismic response of belted high-rise building structures within the framework of the response spectrum technique. The first 3-modes of vibration are considered. Natural periods, internal forces and deflections are computed, and design charts are presented for the parameters of interest. Based on the Applied Technology Council tentative seismic provisions, a numerical example is worked out to illustrate the use of the charts, and a comparison is made with the ATC equivalent lateral force procedure.

79-2249

The Buffeting of Tall Structures by Strong Winds, Windload Program

E. Simiu and D.W. Lozier

Center for Bldg. Technology, National Engrg. Lab (NBS), Washington, D.C., Rept. No. NBS/DF-79/001 (1979)
PB-294 757/0GA

Key Words: Buildings, Wind-induced excitation, Computer programs

A computer program is presented for the calculation of the along-wind response of tall buildings. Program input includes building dimensions, natural frequencies, damping coefficients, modal shapes, and weight distribution, design wind speed, roughness of surrounding terrain, pressure coefficients on windward and leeward faces, and specific weight of air. The output consists of mean, rms, and peak deflections, and rms and peak accelerations.

FOUNDATIONS AND EARTH

79-2250

Turbomachinery Foundations Practical Aspects

J.S. Sohre

One Lakeview Circle, Ware, MA 01082, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 129-137, 10 figs, 2 refs

Key Words: Machine foundations, Turbomachinery

This presentation explains the practical and theoretical requirements for the design of foundations for high speed machinery.

79-2251

Vertical and Torsional Stiffnesses of Cylindrical Footings

E. Kausel and R. Ushijima

Constructed Facilities Div., Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. R79-6, 73 pp (Feb 1979)
PB-293 997/3GA

Key Words: Footings, Torsional response

A numerical evaluation of the vertical and torsional stiffnesses of a cylindrical foundation embedded in an elastic stratum is presented. Empirical formulas are given that relate stiffnesses and damping values with the embedment ratio and the depth of the stratum. Good agreement is found between the reported approximations and available analytical solutions for particular geometries.

79-2252
Analysis of Lateral Response of Non-Uniform Section Piles
H.G. Poulos and M.A. Adler
Civil Engrg. Labs., Sydney Univ., Australia, Rept. No. R-330, 37 pp (Oct 1978)
PB-294 255/5GA

Key Words: Pile structures, Lateral response, Finite element technique, Finite difference theory

Two alternative methods of analyzing the lateral response of a pile of non-uniform section in an elasto-plastic soil mass are presented. The first utilizes a finite element formulation for the pile while the second uses a finite difference formulation. Some parametric solutions are presented for a uniformly tapered pile, and these are presented as correction factors to the solutions for uniform section piles. Finally, two practical examples are given to illustrate the application of the analysis.

79-2253
Dynamic Response of Elastic Plates on the Surface of the Half-Space
S.A. Savidis and T. Richter
Inst. of Soil Mechanics and Foundation Engrg., Technical Univ., Berlin, Germany, Intl. J. Numer. Anal. Methods Geomech., 3 (3), pp 245-254 (July-Sept 1979) 8 figs, 13 refs

Key Words: Interaction: soil-foundation, Half-space, Foundations

A mixed method for the dynamic calculation of foundations on soil is presented. The half-space is computed analytically, the foundation with finite elements. The method is very we'l suited for the solution of three-dimensional problems including interaction. Numerical results for a simple case involving a dynamically loaded elastic plate are presented and the influence of plate stiffness is studied.

HELICOPTERS

(Also see Nos. 2243, 2246, 2285)

79-2254
Fatigue of Helicopters: Service Life Evaluation Method
F. Liard
Helicopter Div., Societe Nationale Industrielle Aerospatiale, Paris, France, In: AGARD Helicopter Fatigue, pp 47-69 (Feb 1979)
N79-23079

Key Words: Helicopters, Fatigue tests

The general principle of fatigue substantiation for helicopter com onents consists in evaluating the fatigue strength of the component, determining the value and frequency of the loads to which it will be subjected during normal operation, and then deriving from these data the steps to be taken to make the possible occurrence of serious accidents due to the failure of the component extremely remote.

79-2255
Present Fatigue Analysis and Design of Helicopters. Requirements and Qualification Procedures
P. Alli
Costruzioni Aeronautiche Giovanni Agusta S.p.A., Gallarate, Italy, In: AGARD Helicopter Fatigue, pp 29-46 (Feb 1979)
N79-23078

Key Words: Helicopters, Fatigue tests

The state-of-the-art in AGUSTA in the area of structural fatigue and fail-safe strength evaluation is reported. The need of general regulations and procedures was pointed out. The convenience of automatic procedures was underlined.

79-2256
Fatigue Life Estimation Methods for Helicopter Structural Parts
F. Och
Messerschmitt-Boelkow-Blohm G.m.b.H., Munich, West Germany, In: AGARD Helicopter Fatigue, pp 21-27 (Feb 1979)
N79-23077

Key Words: Helicopters, Fatigue tests

Analytical fatigue life estimation mainly consists of three steps: prediction of loads, determination of fatigue strength, and application of a damage hypothesis linking these two aspects. Following the above mentioned three steps of fatigue life investigation, methods for the prediction of

loads are dealt with according to the available amount of information. Methods describing the fatigue strength of components, taking into account the influence of steady loads and the reduction of a mean S/N curve to a working level curve are investigated.

79-2257

Helicopter Fatigue Evaluation. The UK Approach

A.D. Hall

Westland Helicopters Ltd., Yeovil, UK, In: AGARD Helicopter Fatigue, pp 13-20 (Feb 1979)

N79-23076

Key Words: Helicopters, Fatigue tests

The philosophies of fatigue substantiation are used satisfactorily for the Lynx. The main concern is with the safe fatigue life substantiation of the vital components of a helicopter and consideration is given to three phases in the life cycle, i.e., design, development, and production.

79-2258

U.S. Army Helicopter Fatigue Requirements and Substantiation Procedures

R.A. Wolfe and R.W. Arden

Structures and Aeromechanics Branch, Army Aviation Res. & Dev. Command, St. Louis, MO, In: AGARD Helicopter Fatigue, pp 1-12 (Feb 1979)

N79-23075

Key Words: Helicopters, Fatigue tests

The current fatigue criteria and testing requirements are provided for U.S. Army helicopter structures with primary emphasis on dynamic components. The comparative industry applications of the requirements were brought to light as a result of the Army's latest major helicopter competitions for the Utility Tactical Transport Aircraft System, recently designated BLACK HAWK, and the Advanced Attack Helicopter.

79-2259

Correlation Study Between Vibrational Environmental and Failure Rates of Civil Helicopter Components

O. Alaniz

Textron Bell Helicopter, Fort Worth, TX, Rept. No. NASA-CR-159033, 75 pp (May 1979)

N79-23064

Key Words: Helicopters, Vibration control

An investigation of two selected helicopter types, namely, the Models 206A/B and 212, is reported. An analysis of the available vibration and reliability data for these two helicopter types resulted in the selection of ten components located in five different areas of the helicopter and consisting primarily of instruments, electrical components, and other noncritical flight hardware. The potential for advanced technology in suppressing vibration in helicopters was assessed.

79-2260

Rotary-Wing Aerodynamics. Volume 1: Basic Theories of Rotor Aerodynamics with Application to Helicopters

W.Z. Stepniewski

Boeing Vertol Co., Philadelphia, PA, Rept. No. NASA-CR-3082, 302 pp (Jan 1979)

N79-22039

Key Words: Rotary wings, Helicopters, Aerodynamic loads

The concept of rotary-wing aircraft in general is defined. The energy effectiveness of helicopters is compared with that of other static thrust generators in hover, as well as with various air and ground vehicles in forward translation. The most important aspects of rotor-blade dynamics and rotor control are reviewed. The combined blade-element and momentum theory approach is described as well as the vortex theory which models a rotor blade by means of a vortex filament or vorticity surface. The application the the velocity and acceleration potential theory to the determination of flow fields around three dimensional non-rotating bodies as well as to rotor aerodynamic problems is described. Airfoil sections suitable for rotors are also considered.

HUMAN

(See No. 2278)

ISOLATION

79-2261
Optimal Design of an Earthquake Isolation System
M.A. Bhatti, K.S. Pister, and E. Polak
Earthquake Engrg. Research Ctr., California Univ., Richmond, CA, Rept. No. UCB/EERC-78/22, NSF/RA-780544, 120 pp (Oct 1978)
PB-294 735/6GA

Key Words: Isolators, Buildings, Seismic design, Earthquake resistant structures, Energy absorption

Optimal design of an earthquake isolation system, consisting of natural rubber bearings and special nonlinear energy absorbing devices, is presented. An algorithm for efficient analysis of structural response, based upon the Newmark and Runge-Kutta methods with optional Newton-Raphson iteration, is given. The optimal design problem, incorporating this simulation algorithm, is formulated as a mathematical programming problem with time-dependent constraints and is solved using a feasible directions algorithm. Several numerical examples are presented.

MECHANICAL

79-2262
Don't Forget the Basics
J.P. Platt, Jr.
Standard Oil Co. (Indiana), Naperville, IL, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 51-55, 3 tables

Key Words: Machinery vibration

This paper presents five simple machinery vibration problems. It is the intent of this paper to make the modern machinery vibration analyst more effective by re-focusing his attention on the basics of machinery vibration problems.

PUMPS, TURBINES, FANS, COMPRESSORS

(Also see No. 2176)

79-2263
Computer Aided Design of Mixed Flow Turbines for Turbochargers
N.C. Baines, F.J. Wallace, and A. Whitfield
Dept. of Engrg., Univ. of Bath, Bath, UK, J. Engr. Power, Trans. ASME, 101 (3), pp 440-449 (June 1979) 10 figs, 1 table, 16 refs

Key Words: Turbines, Computer-aided techniques, Design techniques

The paper describes a comprehensive computer aided design procedure and its use to investigate mixed flow turbines for automotive turbocharger applications. The outside dimensions of rotor and casing as well as blade angles are determined from one-dimensional design and off design calculations, the detailed blade shape from quasi-three-dimensional analysis and mechanical stressing and vibration programs, and geometric data are presented as outside views and sections of the rotor by a graphics subroutine.

79-2264
Low Frequency Gas Turbine Noise
J.R. Newman and K.I. McEwan
British Gas, Hinckley, UK, ASME Paper No. 79-GT-196

Key Words: Gas turbine engines, Noise generation, Low frequencies

British Gas has experienced problems at some installations from low frequency turbine noise. The paper describes how the low frequency noise problems were investigated and then resolved by aerodynamic modifications and a silencer extension.

79-2265
Instability Problem in a High Pressure Ammonia Syn-Gas Compressor
F.C. Aguilar
Instituto Mexicano del Petroleo, Mexico City, Mexico, Machinery Vibration Monitoring and Analysis

Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 63-71, 22 figs, 4 refs

Key Words: Compressors, Vibration response

This paper deals with the vibration problems experimented in a high pressure compressor installed in an ammonia plant of a large Pemex Petrochemical Complex located in the southeast part of Mexico. The various analytical studies, the field and laboratory analysis performed by the Instituto Mexicano del Petróleo IMP to pinpoint the cause of the problem, including a brief description of present rotor dynamics capabilities, are described. Some orbit shapes, acceleration and displacement frequency spectrums and other graphic results as unbalance response and Bode plots are illustrated. Finally, the corrective actions recommended by the compressor manufacturer and the current unit behavior are discussed.

RAIL

79-2266

Urban Rail Noise Abatement Program: A Description

L.G. Kurzweil and W.N. Cobb

Transportation Systems Center, Cambridge, MA, Rept. No. DOT-TSC-UMTA-79-23, UMTA-MA-06-0099-79-1, 26 pp (Mar 1979)

PB-295 545/8GA

Key Words: Rail transportation, Noise reduction

This report presents the background, current activities, and future plans for the Urban Rail Noise Abatement Program. This program, sponsored by the Office of Technology Development and Deployment of the Urban Mass Transportation Administration (UMTA) was initiated in 1972 and has been technically managed by the Transportation Systems Center. The problem of urban rail noise and vibration is described and the rationale for the UMTA funded program is given. The body of the report presents a definition of the program objectives, a discussion of the program organization, and a description of past, current, and future program activities. Major accomplishments of the program to date are listed in the final section.

79-2267

Dynamic Theories and Experiments of Alternative Guideway-Vehicle Systems. Part II

J.F. Wilson

Dept. of Civil Engrg., Duke Univ., Durham, NC, Rept. No. DOT/RSPA/DPB/50-79/4, 189 pp (Mar 1979)

PB-294 247/2GA

Key Words: Interaction: vehicle-guideway

In both the companion report (Part I) and the present study, the broad purpose is to investigate theoretically and experimentally guideway-vehicle system dynamics. Four alternative systems are studied in terms of nondimensional parameters.

REACTORS

79-2268

Analysis of Containment Structures for Randomly Arriving Transient Loads

M.P. Singh and A. Al-Dabbagh

Dept. of Engrg. Science and Mechanics, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, Engrg. Struc., 1 (4), pp 197-202 (July 1979) 7 figs, 4 refs

Key Words: Containment structures, Nuclear reactor containment, Hydrodynamic excitation

Hydrodynamic loads such as those due to safety relief valve discharges and a postulated accidental loss of coolant are some of the major loads on boiling water reactor (BWR) containments. The formulation of the response transfer function approach is developed for axisymmetric containment structures. The formulation to obtain the mean and standard deviation of response for uniformly distributed load arrival time is also provided and the numerical results for a typical BWR containment are given.

79-2269

A Comparison of Background Seismic Risks and the Incremental Seismic Risk Due to Nuclear Power Plants

Y.T. Lee, D. Okrent, and G. Apostolakis

School of Engrg. and Applied Science, Univ. of California, Los Angeles, CA 90024, Nucl. Engr. Des., 53 (1), pp 141-154 (June 1979) 3 figs, 7 tables, 44 refs

Key Words: *Nuclear power plants, Seismic response*

The seismic risk for the continental United States, in terms of the expected annual number of deaths and severe injuries, and the expected property damage, is evaluated in this work. Probabilistic models and correlations are developed and used in the evaluations of the risks, accounting for such important variables as the variability of property values, damage factors and so on. In addition, the incremental seismic risk due to the presence of nuclear power plants is evaluated utilizing results and methods available in the literature.

RECIPROCATING MACHINE

(Also see Nos. 2173, 2174)

79-2270

Engine Evaluation of a Vibration Damping Treatment for Inlet Guide Vanes

J.P. Henderson, L.C. Rogers, D.B. Paul, and M.L. Parin

Wright-Patterson AFB, OH, ASME Paper No. 79-GT-163

Key Words: Engine vibration, Vibration damping

This paper describes the results of engine test-cell tests and the comparison of these results with actual service experience obtained under operational conditions. Measured effects on engine performance, distortion tolerance, and anti-icing performance are presented along with measured stress reductions, as compared with increases in modal damping. Durability design considerations are discussed, along with the results of durability tests in an engine test stand and actual service experience.

79-2271

Knock-Induced Cavity Resonances in Open Chamber Diesel Engines

R. Hickling, D.A. Feldmaier, and S.H. Sung

Engrg. Mechanics Dept., General Motors Research Labs., Warren, MI 48090, J. Acoust. Soc. Amer., 65 (6), pp 1474-1479 (June 1979) 10 figs, 2 tables, 7 refs

Key Words: Diesel engines, Engine noise, Cavity resonators

Cavity resonances are investigated in detail for six open-chamber diesel engines of different sizes. Spectral data are obtained from cylinder pressure-time traces and compared with predictions from finite-element calculations of the cavity resonances. Good agreement is found.

ROAD

79-2272

Nonlinear Rebound of a Rod After Impact Against a Deformable Barrier

H. Garnet and H. Armen

Research Dept., Grumman Aerospace Corp., Bethpage, NY, Intl. J. Numer. Methods Engr., 14 (7), pp 1037-1050 (1979) 8 figs, 10 refs

Key Words: Collision research (automotive), Guardrails, Ground vehicles, Mathematical models

The nonlinear impact of a vehicle against a deformable barrier and its subsequent rebound from that barrier are simulated. A one-dimensional elastoplastic model represents the vehicle as a series of rod finite elements and the barrier as a single mass, nonlinear spring. The solution procedure utilizes variable time step integration, contains an error control and eliminates numerical instabilities. A limited study assesses the influence of system parameters on both structure and occupants. The chief objective is to establish the feasibility of the proposed treatment of this class of problems.

79-2273

Task 4 Test Report for Development of Compliance Test for Truck Rear Underride Protection

R. Baczynski and S. Davis

Dynamic Science, Inc., Phoenix, AZ, Rept. No. 8319-78-149A, DOT-HS-803 991, 261 pp (Sept 1978)

PB-294 785/1GA

Key Words: Trucks, Collision research (automotive), Experimental data

This report presents the results of the six passenger car-to-rear underride crash tests conducted in accordance with the requirements of Task 4 of the 'Development of Compliance Test for Truck Rear Underride Protection' program. The test vehicles selected for Task 4 tests were 1978 VW Rabbit and 1978 Chevrolet Impala four-door sedans.

79-2274
Task 5 Report of Tests 5.1, 5.2, and 5.3 for Development of Compliance Test for Truck Rear Underride Protection
R. Baczynski, S. Davis, and R. Cropper
Dynamic Science, Inc., Phoenix, AZ, Rept. No. 8319-78-193A, DOT-HS-803 990, 162 pp (Nov 1978)
PB-294 831/3GA

Key Words: Collision research (automotive), Experimental data

This report presents the results of the first three of eight passenger car-to-rear underride crash tests conducted in accordance with the requirements of Task 5 of the 'Development of Compliance Test for Truck Rear Underride Protection' program. The test vehicles selected for these tests were 1978 VW Rabbits and a 1978 Ford Fiesta. These vehicles were impacted into bolt-on, rigid, cantilevered guards mounted to a truck/trailer body simulator at selected heights above ground level.

79-2275
Vibration Tests on Transit Buses
J. Anderson and H. Thomas
Gould Information Identification, Inc., Fort Worth, TX, Rept. No. UMTA-MA-06-0041-79-6, DOT-TSC-UMTA-79-13, 56 pp (Mar 1979)
PB-295 091/3GA

Key Words: Buses, Vibration measurement

The objective of this vibration measurement program is to quantify the vibration environment which is experienced by Automatic Vehicle Monitoring (AVM) equipment when installed on buses during typical city route service operations. Two buses are utilized in this measurement program; a General Motors Corporation Model 3100 provided by the Southern California Rapid Transit District, and a Flexible Corporation Model 207 provided by the City Transit of Fort Worth, Texas. The approach taken involved instrumenting the buses and representative electronic hardware on the buses with calibrated accelerometers and recording the output of these accelerometers while driving the buses over selected test routes at specified speeds.

79-2276
Improvement of Shock Measurements for Armored Vehicles - ILIR Task 4
W.S. Walton
Aberdeen Proving Ground, MD, Rept. No. APG-MT-5192, 64 pp (Jan 1979)
AD-A066 303/9GA

Key Words: Shock tests, Shock measurement, Armored vehicles

A study was conducted at Aberdeen Proving Ground from April to September 1978. Data from piezoelectric and piezoresistive accelerometers subjected to short duration shocks were analyzed. Various configurations and materials were used to mechanically filter out high-frequency acceleration.

79-2277
Optimal Control Concepts for the Characterization and Design of Highway Vehicle-Trailer Systems
M.A. Townsend, A.B. Shapiro, and K.T.A. Ho
Dept. of Mech. Engrg. and Materials Science, Vanderbilt Univ., Nashville, TN, J. Dyn. Syst., Meas. and Control, Trans. ASME, 101 (2), pp 127-137 (June 1979) 11 figs, 41 refs

Key Words: Articulated vehicles, Dynamic stability, Optimum control theory

In this paper, design concepts are developed from optimal control theory to provide criteria for comparison and are then applied to one of the more innovative and potentially competitive concepts in commercial trucking: the multiple-trailer highway vehicle train. The definition of relevant models is given and criteria are then developed. Their applicability is demonstrated by the posing of optimal unloading schedules to improve dynamic performance, the sensitivity of such designs to changes in system parameters, and the design synthesis of couplers between the system components.

ROTORS

(Also see Nos. 2154, 2161, 2164)

79-2278
Calculation of Rotor Impedance for Articulated-Rotor Helicopters in Forward Flight
K. Kato and T. Yamane
Univ. of Tokyo, Tokyo, Japan, J. Aircraft, 16 (7), pp 470-476 (July 1979) 8 figs, 5 refs

Key Words: Helicopters, Mechanical impedance, Flexible rotors, Rotors (machine elements)

A procedure is presented to calculate the loads transferred from an articulated flexible rotor to the fuselage when the hub is forced to oscillate sinusoidally. Blade motions are determined from a set of linear algebraic equations derived from equations of motion with periodic coefficients. The aerodynamic loads are based on two-dimensional quasisteady strip theory.

79-2279
Engine Rotor Dynamics, Synchronous and Non-synchronous Whirl Control
R.A. Marmol
Government Products Div., Pratt and Whitney Aircraft Group, West Palm Beach, FL, Rept. No. FR-10632, USARTL-TR-79-2, 149 pp (Feb 1979) AD-A066 093/6GA

Key Words: Rotors (machine elements), Turbine components, Design techniques, Mathematical models, Experimental results

A combined analytical and test program is performed to develop a method of designing highspeed power turbine rotors to minimize rotor-induced dynamic loads under normal operating conditions; minimize rotor tip-to-shroud clearance to maintain high flow-path efficiency; and minimize rotor deflections due to sudden abusive imbalance loads associated with blade loss. Using the results of the analytical models and experimental tests, a method of design optimization is developed to obtain the best trade-off between all the rotor design variables considered in this program.

SHIP

79-2280
Response Analysis of a Moored Open-Bottom Floating Platform to Random Loadings
S.S. Fang
Ph.D. Thesis, Columbia Univ., 94 pp (1979)
UM 7916402

Key Words: Off-shore structures, Random excitation, Time domain method, Harmonic excitation, Seismic excitation, Wind-induced excitation

The dynamic response of a moored open-bottom floating platform to random loading is examined by a time-domain simulation technique. The equations of motion of the floating platform in the time domain are derived from the impulse response method which takes into consideration the frequency dependence of the fluid reaction force terms, i.e., added mass and damping force coefficients. The sway and roll responses of the moored platform to random environmental loadings are evaluated by solving the equations of motion. The hydrodynamic coefficients of the open-bottom platform, with pressurized subdivided air chambers having a free air-water interface, are evaluated by a modified Frank's close fit method. Numerical examples of the motion response of the floating platform, to harmonic excitation, random wind loading and earthquake are illustrated and discussed in this study.

79-2281
Spectral Dynamic Fatigue Analysis of the ANDOC Dunlin A Platform
D. Zijp
Volker Sterin Civil Engrg. and Construction, P.O. Box 3, 1940 AA Beverwijk, The Netherlands, Engrg. Struc., 1 (4), p 211 (July 1979) 15 figs, 2 refs

Key Words: Offshore structures, Fatigue life, Computer programs

The necessary computer programs have been developed by the IBM computer center in Zoetermeer and have been extensively tested by the ANDOC design team, using the Dunlin A geometry. A comparison is made between deterministic and a spectral analysis as well as between the harmonic solution and time step integration.

SPACECRAFT

79-2282
Flight Vibration Environments Defined From Mk 12 Booster Static Tests
N. Rubinstein and W.C. Caywood
Appl. Physics Lab., The Johns Hopkins Univ., Laurel, MD, J. Spacecraft Rockets, 16 (4), pp 214-217 (July/Aug 1979) 4 figs, 4 tables, 4 refs

Key Words: Booster rockets, Vibration tests

Results of a static firing test program concerning the environmental effects of rough burning of the Mk12 rocket motor booster on the Standard Missile components are discussed. Vibration and pressure data were recorded and processed using methods of time series analyses. The test procedures, methods of data processing, and significant results are presented. The results show good agreement with flight vibration data and theoretical acoustic pressure frequencies.

STRUCTURAL

79-2283

Theoretical Study of the Dynamic Response of a Chimney to Earthquake and Wind

L. Shiau

Ph.D. Thesis, Purdue Univ., 168 pp (1978)
UM 7914971

Key Words: Chimneys, Earthquake response, Wind-induced excitation

An analytical investigation of the response of a chimney to earthquake and wind is presented. The 823 foot tall chimney is modeled using Bernoulli-Euler beam finite elements. The modal superposition method is used for analyzing the elastic response while the numerical direct integration method is used to solve the equations for the inelastic response. A mathematical model that enables one to predict the vortex-excited resonant responses of two cylinders in line in the wind direction is developed.

79-2284

Earthquake-Induced Sloshing in Axisymmetric Tanks

M. Aslam

Ph.D. Thesis, Univ. of California, 281 pp (1978)
UM 7914532

Key Words: Tanks (containers), Fluid-filled containers, Sloshing, Dams, Off-shore structures, Seismic excitation

The present study was motivated by the concern about possible effects of seismic-sloshing in pressure-suppression pools of boiling water reactors. These suppression pools may be designed as annular or torus tanks. An analysis to predict the sloshing displacements and impulsive pressures in annular tanks, and a finite element technique applicable to all axisymmetric tanks with rigid walls and subjected to horizontal ground motions are presented.

79-2285

Dynamic Structural Analysis with Substructures

J.S. Arora and D.T. Nguyen

Div. of Materials Engrg., Univ. of Iowa, Iowa City, IA, Rept. No. TR-46, 34 pp (Dec 1978)
AD-A065 937/5GA

Key Words: Dynamic structural analysis, Finite element technique, Natural frequencies, Mode shapes, Helicopters

A method for dynamic structural analysis with substructures and the subspace iteration is developed. The method uses only substructural stiffness matrices and the mass matrix for each finite element of the system.

TRANSMISSIONS

79-2286

Keeping Hydrostatic Transmissions Quiet

S.J. Skaistis

Sperry-Vickers Div. of Sperry Rand Corp., Troy, MI, Diesel Gas Turbine Prog., 45 (8), pp 24-25 (Aug 1979) 7 figs

Key Words: Transmission systems, Noise reduction

Existing technology for the airborne, fluidborne, and structureborne noise abatement in hydrostatic transmissions is discussed.

TURBOMACHINERY

(Also see Nos. 2171, 2172)

79-2287

Rotor Critical Speed and Response Studies for Equipment Selection

C. Jackson and M.E. Leader

Monsanto Co., Texas City, TX, Machinery Vibration Monitoring and Analysis Seminar and Mtg., Proc., Sponsored by Vibration Inst., Apr 1979, New Orleans, LA, pp 43-50, 17 figs

Key Words: Turbomachinery, Turbine components, Critical speeds, Unbalanced mass response

This paper addresses some of the latest techniques available for turbomachinery analysis.

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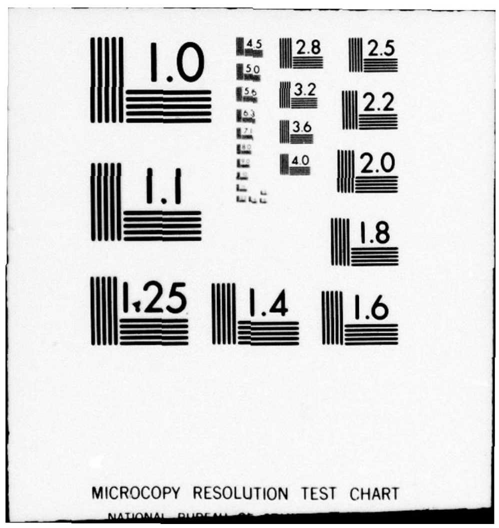
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2203 2256

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420	401	482	443	424	445	1046	397	418	499
580	561	492	483	444	905	1186	707	558	739
740	741	562	723	684	1005	1366	987	718	819
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2050	1761	2252	1553	1904	1925		1947	1408	1789
	1791		1793		1935			1828	1879
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						2036			

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						2166			

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90	91	102	323	284	95	126	87	128	789
280	321	642	833	324	295	326	127	828	1179
490	701	812	1603	484	485	486	597	1208	1209
1180	1021	1602	1833	1324	2115	616	787		1709
1410	2031	1812	2033	1394		826	1017		
1550				1754		1136	1817		
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310 641 1202 724 445 1416 1387 768 309
1040 1201 1074 945 2186 1607 878 319
1460 1801 1184 1075 1627 1328 609
1520 2024 1155 2047 1568 709
1600 1185 2137 1638 769
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2070 1639
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1699
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2019
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1261 352 1843 1964 1035 1226 607 1289
1971 462 2023 2064 1365 1716 1037 1359
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Issue:	1	2	3	4	5	6	7	8	9	10	11	12

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Volume 11												
Issue:	1	2	3	4	5	6	7	8	9	10	11	12

TECHNICAL NOTES

B.R. Mace
The Evaluation of Infinite Sums with Special Reference to the Response of a Simply Supported Beam
J. Sound Vib., 63 (4), pp 597-601 (Apr 22, 1979)
2 figs, 7 refs

H.R. Srirangarajan
Pulse Response of a Non-Linear System
J. Sound Vib., 63 (4), pp 593-596 (Apr 22, 1979)
1 fig, 7 refs

A. Michalke and U. Michel
Relation Between Static and In-Flight Directivities of Jet Noise
J. Sound Vib., 63 (4), pp 602-605 (Apr 22, 1979)
3 figs, 3 refs

A. Brot
A Dynamic Analysis of Landing Impact
Israel J. Tech., 16 (3), pp 154-158 (1978) 3 figs, 3 refs

E.P. Chen
Transient Behavior of a Cracked Orthotropic Cylinder Under Torsion
J. Appl. Mech., Trans. ASME, 46 (2), pp 472-473 (June 1979) 3 refs

H. Lecoanet and J. Piranda
In-Plane Vibrations of Thick Circular Rings with T or I Cross Sections
J. Appl. Mech., Trans. ASME, 46 (2), pp 470-472 (June 1979) 2 figs, 7 refs

K. Itao and S.H. Crandall
Natural Modes and Natural Frequencies of Uniform, Circular, Free-Edge Plates
J. Appl. Mech., Trans. ASME, 46 (2), pp 448-453 (June 1979) 1 table, 5 refs

M. Lakshmanan
On a Non-Linear Harmonic Oscillator
J. Sound Vib., 64 (3), pp 458-461 (June 8, 1979)
8 refs

P.A.A. Laura and L. Luisoni
Approximate Solution of the Two-Dimensional Helmholtz Equation in the Case of Convex Polygonal Domains
J. Sound Vib., 64 (3), pp 451-454 (June 8, 1979)
2 figs, 3 refs

F. Culick and K. Magiawala
Excitation of Acoustic Modes in a Chamber by Vortex Shedding
J. Sound Vib., 64 (3), pp 455-457 (June 8, 1979)
2 figs, 2 refs

M.S. Naschie and S. Al Athel
Remarks on the Stability of Flexible Rods Under Follower Forces
J. Sound Vib., 64 (3), pp 462-465 (June 8, 1979)
3 figs, 7 refs

G.J. Erickson
Some Frequencies of Underwater Noise Produced by Fishing Boats Affecting Albacore Catch
J. Acoust. Soc. Amer., 66 (1), pp 296-299 (July 1979) 5 figs, 1 table, 2 refs

J. Mazumdar
Comments on "Estimation of Fundamental Frequency of Non-Circular Plates with Free Circular Cutouts"
J. Sound Vib., 65 (1), pp 145-146 (July 8, 1979)
1 fig, 3 refs

S. Ko and C.H. Sherman
Flexural Wave Baffling
J. Acoust. Soc. Amer., 66 (2), pp 566-570 (Aug 1979) 4 figs, 8 refs

W.E. Cundiff
Simulating System Dynamics in APL
Appl. Math. Modeling, 3 (4), pp 312-314 (Aug 1979)
4 figs, 5 refs

K. Singh and B.L. Dhoopar
Free Vibration of Circular Rings on Radial Supports
J. Sound Vib., 65 (2), pp 297-301 (July 22, 1979)
1 fig, 1 table, 3 refs

PERIODICALS SCANNED

PUBLICATION AND ADDRESS	ABBREVIATION
ACTA MECHANICA Springer-Verlag New York, Inc. 175 Fifth Ave. New York, NY 10010	Acta Mech.
ACUSTICA S. Hirzel Verlag, Postfach 347 D-700 Stuttgart 1 W. Germany	Acustica
AERONAUTICAL JOURNAL Royal Aeronautical Society 4 Hamilton Place London W1V 0BQ, UK	Aeronaut. J.
AERONAUTICAL QUARTERLY Royal Aeronautical Society 4 Hamilton Place London W1V 0BQ, UK	Aeronaut. Quart.
AIAA JOURNAL American Institute of Aeronautics and Astronautics 1290 Avenue of the Americas New York, NY 10019	AIAA J.
AMERICAN SOCIETY OF CIVIL ENGINEERS, PROCEEDINGS Publications Office, ASCE United Engineering Center 345 East 47th St. New York, NY 10017	
JOURNAL OF ENGINEERING MECHANICS DIVISION	ASCE J. Engr. Mech. Div.
JOURNAL OF ENVIRONMENTAL ENGINEERING DIVISION	ASCE J. Environ. Engr. Div.
JOURNAL OF GEOTECHNICAL ENGINEERING DIVISION	ASCE J. Geotech. Engr. Div.
JOURNAL OF HYDRAULICS DIVISION	ASCE J. Hydraulics Div.
JOURNAL OF IRRIGATION AND DRAINAGE DIVISION	ASCE J. Irrigation Drainage Div.
JOURNAL OF STRUCTURAL DIVISION	ASCE J. Struc. Div.
JOURNAL OF TRANSPORTATION ENGINEERING DIVISION	ASCE J. Transport. Engr. Div.
AMERICAN SOCIETY OF LUBRICATING ENGINEERS, TRANSACTIONS Academic Press 111 Fifth Ave. New York, NY 10019	ASLE, Trans.
AMERICAN SOCIETY OF MECHANICAL ENGINEERS, TRANSACTIONS United Engineering Center 345 East 47th St. New York, NY 10017	
JOURNAL OF APPLIED MECHANICS	J. Appl. Mech., Trans. ASME
JOURNAL OF DYNAMIC SYSTEMS, MEASUREMENT AND CONTROL	J. Dyn. Syst., Meas. and Control, Trans. ASME
JOURNAL OF ENGINEERING FOR INDUSTRY	J. Engr. Indus., Trans. ASME
JOURNAL OF ENGINEERING FOR POWER	J. Engr. Power, Trans. ASME
JOURNAL OF LUBRICATION TECHNOLOGY	J. Lubric. Tech., Trans. ASME
JOURNAL OF MECHANICAL DESIGN	J. Mech. Des., Trans. ASME
JOURNAL OF PRESSURE VESSEL TECHNOLOGY	J. Pressure Vessel Tech., Trans. ASME
APPLIED ACOUSTICS Applied Science Publishers, Ltd. Ripple Road, Barking Essex, UK	Appl. Acoust.
APPLIED MATHEMATICAL MODELING IPC House 32 High St., Guildford Surrey GU1 3EW, UK	Appl. Math. Modeling
ARCHIVES OF ACOUSTICS Polish Academy of Sciences Committee on Acoustics Polish Acoustical Society	Arch. Acoust.
ARCHIVES OF MECHANICS (ARCHIWUM MECHANIKI STOSOWANEJ) Export and Import Enterprise Ruch UL, Wronia 23, Warsaw, Poland	Arch. Mech.
ASTRONAUTICS AND AERONAUTICS AIAA EDP 1290 Avenue of the Americas New York, NY 10019	Astronaut. & Aeronaut.
AUTOMOBILTECHNISCHE ZEITSCHRIFT Franckh'sche Verlagshandlung Abteilung Technik 7000 Stuttgart 1, Pfizerstrasse 5-7 W. Germany	Automobiltech. Z.

PUBLICATION AND ADDRESS	ABBREVIATION
AUTOMOTIVE ENGINEER (SAE) Society of Automotive Engineers, Inc. 400 Commonwealth Drive Warrendale, PA 15096	Auto. Engr. (SAE)
AUTOMOTIVE ENGINEER (UK) P.O. Box 24, Northgate Ave. Bury St., Edmunds Suffolk IP21 GBW, UK	Auto. Engr. (UK)
BALL BEARING JOURNAL (English Edition) SKF (U.K.) Ltd. Luton, Bedfordshire LU3 1JF, UK	Ball Bearing J.
BROWN BOVERI REVIEW Brown Boveri and Co., Ltd. CH-5401, Baden, Switzerland	Brown Boveri Rev.
BULLETIN DE L'ACADEMIE POLONAISE DES SCIENCES, SERIES DES SCIENCES TECHNIQUES Ars Polona-Ruch 7 Krokowskie Przedmiescie, Poland	Bull. Acad. Polon. Sci., Ser. Sci. Tech.
BULLETIN OF JAPAN SOCIETY OF MECHANICAL ENGINEERS Japan Society of Mechanical Engineers Sanshin Hokusei Bldg. H-9 Yoyogi 2-chome Shibuya-ku Tokyo 151, Japan	Bull. JSME
BULLETIN OF SEISMOLOGICAL SOCIETY OF AMERICA Bruce A. Bolt Box 826 Berkeley, CA 94705	Bull. Seismol. Soc. Amer.
CIVIL ENGINEERING (NEW YORK) ASCE Publications Office 345 E. 47th St. New York, NY 10017	Civ. Engr. (N.Y.)
COMPUTERS AND STRUCTURES Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Computers Struc.
DESIGN NEWS Cahners Publishing Co., Inc. 221 Columbus Ave. Boston, MA 02116	Des. News
DIESEL AND GAS TURBINE PROGRESS Diesel Engines, Inc. P.O. Box 7406 Milwaukee, WI 53213	Diesel Gas Turbine Prog.
ENGINEERING MATERIALS AND DESIGN IPC Industrial Press Ltd. 33-40 Bowling Green Lane London EC1R, UK	Engr. Matl. Des.
EXPERIMENTAL MECHANICS Society for Experimental Stress Analysis 21 Bridge Sq., P.O. Box 277 Westport, CT 06880	Exptl. Mech.
FORSCHUNG IM INGENIEURWESEN Verein Deutscher Ingenieur, GmbH Postfach 1139, Graf-Recke Str. 84 4 Duesseldorf 1 W. Germany	Forsch. Ingenieurw.

PUBLICATION AND ADDRESS	ABBREVIATION
HEATING/PIPING/AIR CONDITIONING Circulation Dept. 614 Superior Ave. West Cleveland, OH 44113	Heating/ Piping/ Air Cond.
HYDRAULICS AND PNEUMATICS Penton/IPC, Inc. 614 Superior Ave., West Cleveland, OH 44113	Hydraulics & Pneumatics
HYDROCARBON PROCESSING Gulf Publishing Co. Box 2608 Houston, TX 77001	Hydrocarbon Processing
IBM JOURNAL OF RESEARCH AND DEVELOPMENT International Business Machines Corp. Armonk, NY 10504	IBM J. Res. Dev.
INDUSTRIAL RESEARCH Dun-Donnelley Publishing Corp. 222 S. Riverside Plaza Chicago, IL 60606	Indus. Res.
INGENIEUR-ARCHIV Springer-Verlag New York, Inc. 175 Fifth Ave. New York, NY 10010	Ing. Arch.
INSTITUTE OF MARINE ENGINEERS, TECHNICAL REPORTS The Memorial Building 76 Mark Lane London EC3R 7IN, UK	Inst. Mar. Engr., T.R.
INSTITUTION OF ENGINEERS, AUSTRALIA, CIVIL ENGINEERING TRANSACTIONS 11 National Circuit Barton, A.C.T. 2600 Australia	Instn. Engr., Austral., C.E. Trans.
INSTITUTION OF ENGINEERS, AUSTRALIA, ELECTRICAL ENGINEERING TRANSACTIONS 11 National Circuit Barton, A.C.T. 2600 Australia	Instn. Engr., Austral., E.E. Trans.
INSTITUTION OF ENGINEERS, AUSTRALIA, MECHANICAL ENGINEERING TRANSACTIONS 11 National Circuit Barton, A.C.T. 2600 Australia	Instn. Engr., Austral., M.E. Trans.
INSTITUTION OF MECHANICAL ENGINEERS, (LONDON), PROCEEDINGS Institution of Mechanical Engineers 1 Birdcage Walk, Westminster, London SW1, UK	Instn. Mech. Engr. Proc.
INSTRUMENT SOCIETY OF AMERICA, TRANSACTIONS Instrument Society of America 400 Stanwix St. Pittsburgh, PA 15222	ISA Trans.
INTERNATIONAL JOURNAL OF CONTROL Taylor and Francis Ltd. 10-14 Macklin St. London WC2B 5NF, UK	Intl. J. Control

PUBLICATION AND ADDRESS	ABBREVIATION
INTERNATIONAL JOURNAL OF EARTHQUAKE ENGINEERING AND STRUCTURAL DYNAMICS John Wiley and Sons, Ltd. 650 Third Ave. New York, NY 10016	Intl. J. Earthquake Engr. Struc. Dynam.
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Engr. Sci.
INTERNATIONAL JOURNAL OF MACHINE TOOL DESIGN AND RESEARCH Pergamon Press, Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Mach. Tool Des. Res.
INTERNATIONAL JOURNAL OF MECHANICAL SCIENCES Pergamon Press, Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Mech. Sci.
INTERNATIONAL JOURNAL OF NONLINEAR MECHANICS Pergamon Press, Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Nonlin. Mech.
INTERNATIONAL JOURNAL FOR NUMERICAL METHODS IN ENGINEERING John Wiley and Sons, Ltd. 605 Third Ave. New York, NY 10016	Intl. J. Numer. Methods Engr.
INTERNATIONAL JOURNAL FOR NUMERICAL AND ANALYTICAL METHODS IN GEOMECHANICS John Wiley and Sons, Ltd. Baffins Lane Chichester, Sussex, UK	Intl. J. Numer. Anal. Methods Geomech.
INTERNATIONAL JOURNAL OF SOLIDS AND STRUCTURES Pergamon Press, Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Solids Struc.
ISRAEL JOURNAL OF TECHNOLOGY Weizmann Science Press of Israel Box 801 Jerusalem, Israel	Israel J. Tech.
JOURNAL DE MÉCANIQUE Gauthier-Villars 55 Quai des Grands Augustines, Paris 6, France	J. de Mécanique
JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA American Institute of Physics 335 E. 45th St. New York, NY 10010	J. Acoust. Soc. Amer.
JOURNAL OF AIRCRAFT American Institute of Aeronautics and Astronautics 1290 Avenue of the Americas New York, NY 10019	J. Aircraft

PUBLICATION AND ADDRESS	ABBREVIATION
JOURNAL OF THE AMERICAN HELICOPTER SOCIETY American Helicopter Society, Inc. 30 E. 42nd St. New York, NY 10017	J. Amer. Helicopter Soc.
JOURNAL OF ENGINEERING MATHEMATICS Academic Press 198 Ash Street Reading, MA 01867	J. Engr. Math.
JOURNAL OF ENVIRONMENTAL SCIENCES Institute of Environmental Sciences 940 E. Northwest Highway Mt. Prospect, IL 60056	J. Environ. Sci.
JOURNAL OF FLUID MECHANICS Cambridge University Press 32 East 57th St. New York, NY 10022	J. Fluid Mech.
JOURNAL OF THE FRANKLIN INSTITUTE Pergamon Press, Inc. Maxwell House, Fairview Park Elmsford, NY 10523	J. Franklin Inst.
JOURNAL OF HYDRONAUTICS American Institute of Aeronautics and Astronautics 1290 Avenue of the Americas New York, NY 10019	J. Hydronautics
JOURNAL OF THE INSTITUTE OF ENGINEERS, AUSTRALIA Science House, 157 Gloucter Sydney, Australia 2000	J. Inst. Engr., Austral.
JOURNAL OF MECHANICAL ENGINEERING SCIENCE Institution of Mechanical Engineers 1 Birdcage Walk, Westminster London SW1 H9, UK	J. Mech. Engr. Sci.
JOURNAL OF THE MECHANICS AND PHYSICS OF SOLIDS Pergamon Press, Inc. Maxwell House, Fairview Park Elmsford, NY 10523	J. Mech. Phys. Solids
JOURNAL OF PHYSICS E. (SCIENTIFIC INSTRUMENTS) American Institute of Physics 335 East 45th St. New York, NY 10017	J. Phys. E. (Sci. Instr.)
JOURNAL OF SHIP RESEARCH Society of Naval Architects and Marine Engineers 20th and Northhampton Sts. Easton, PA 18042	J. Ship Res.
JOURNAL OF SOUND AND VIBRATION Academic Press 111 Fifth Ave. New York, NY 10019	J. Sound Vib.

PUBLICATION AND ADDRESS	ABBREVIATION
JOURNAL OF SPACECRAFT AND ROCKETS American Institute of Aeronautics and Astronautics 1290 Avenue of the Americas New York, NY 10019	J. Spacecraft Rockets
JOURNAL OF TESTING AND EVALUATION (ASTM) American Society for Testing and Materials 1916 Race St. Philadelphia, PA 19103	J. Test Eval. (ASTM)
KONSTRUKTION Springer Verlag 3133 Connecticut Ave., N.W. Suite 712 Washington, D.C. 20008	Konstruktion
LUBRICATION ENGINEERING American Society of Lubrication Engineers 838 Busse Highway Park Ridge, IL 60068	Lubric. Engr.
MACHINE DESIGN Penton Publishing Co. Penton Bldg. Cleveland, OH 44113	Mach. Des.
MASCHINENBAUTECHNIK VEB Verlag Technik Oranienburger Str. 13/14 102 Berlin, E. Germany	Maschinenbautechnik
MECCANICA Pergamon Press, Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Meccanica
MECHANICAL ENGINEERING American Society of Mechanical Engineers 345 E. 45th St. New York, NY 10017	Mech. Engr.
MECHANICS RESEARCH AND COMMUNICATIONS Pergamon Press, Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Mech. Res. Comm.
MECHANISM AND MACHINE THEORY Pergamon Press, Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Mech. Mach. Theory
MEMOIRES OF THE FACULTY OF ENGINEERING, KYOTO UNIVERSITY Kyoto University Kyoto, Japan	Mem. Fac. Engr. Kyoto Univ.
MEMOIRES OF THE FACULTY OF ENGINEERING, NAGOYA UNIVERSITY Library, Nagoya University Furo-Cho, Chikusa-ku Nagoya, Japan	Mem. Fac. Engr. Nagoya Univ.
MTZ MOTORTECHNISCHE ZEITSCHRIFT Franckh'sche Verlagshandlung Pfizerstrasse 5-7 7000 Stuttgart 1 W. Germany	MTZ Motortech. Z.

PUBLICATION AND ADDRESS	ABBREVIATION
NAVAL ENGINEERS JOURNAL American Society of Naval Engineers, Inc. Suite 507, Continental Bldg. 1012 - 14th St., N.W. Washington, D.C. 20005	Naval Engr. J.
NOISE CONTROL VIBRATION ISOLATION Trade and Technical Press Ltd. Crown House, Morden Surrey SM4 5EW, UK	Noise Control Vib. Isolation
NOISE CONTROL ENGINEERING P.O. Box 2167 Morristown, NJ 07960	Noise Control Engr.
NORTHEAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS, TRANSACTIONS Bolbec Hall Newcastle upon Tyne 1, UK	NE Coast Instn. Engrs. Shipbldrs., Trans.
NUCLEAR ENGINEERING AND DESIGN North Holland Publishing Co. P.O. Box 3489 Amsterdam, The Netherlands	Nucl. Engr. Des.
OIL AND GAS JOURNAL The Petroleum Publishing Co. 211 S. Cheyenne Tulsa, OK 74101	Oil Gas J.
PACKAGE ENGINEERING 5 S. Wabash Ave. Chicago, IL 60603	Package Engr.
POWER P.O. Box 521 Hightston, NJ 08520	Power
POWER TRANSMISSION DESIGN Industrial Publishing Co. Division of Pittway Corp. 812 Huron Rd. Cleveland, OH 44113	Power Transm. Des.
PRODUCT ENGINEERING (NEW YORK) McGraw-Hill Book Co. P.O. Box 1622 New York, NY	Product Engr. (NY)
QUARTERLY JOURNAL OF MECHANICS AND APPLIED MATHEMATICS Wm. Dawson & Sons, Ltd. Cannon House Folkestone, Kent, UK	Quart. J. Mech. Appl. Math.
REVUE ROUMAINE DES SCIENCES TECHNIQUES, SERIE DE MÉCANIQUE APPLIQUEE Editions De L'Academie De La Republique Socialiste de Roumaine 3 Bis Str., Gutenberg, Bucurest, Romania	Rev. Roumaine Sci. Tech., Mécanique
REVIEW OF SCIENTIFIC INSTRUMENTS American Institute of Physics 335 East 45th St. New York, NY 10017	Rev. Scientific Instr.
SAE PREPRINTS Society of Automotive Engineers Two Pennsylvania Plaza New York, NY 10001	SAE Prepr.

PUBLICATION AND ADDRESS	ABBREVIATION
SIAM JOURNAL ON APPLIED MATHEMATICS Society for Industrial and Applied Mathematics 33 S. 17th St. Philadelphia, PA 19103	SIAM J. Appl. Math.
SIAM JOURNAL ON NUMERICAL ANALYSIS Society for Industrial and Applied Mathematics 33 S. 17th St. Philadelphia, PA 19103	SIAM J. Numer. Anal.
S/V, SOUND AND VIBRATION Acoustic Publications, Inc. 27101 E. Oviat Rd. Bay Village, OH 44140	S/V, Sound Vib.
TECHNISCHES MESSEN - ATM R. Oldenburg Verlag GmbH Rosenheimer Str. 145 8 München 80, W. Germany	Techn. Messen-ATM
TURBOMACHINERY INTERNATIONAL Turbomachinery Publications, Inc. 22 South Smith St. Norwalk, CT 06855	Turbomach. Intl.
VDI ZEITSCHRIFT Verein Deutscher Ingenieur GmbH Postfach 1139, Graf-Recke Str. 84 4 Duesseldorf 1, Germany	VDI Z.
VDI FORSCHUNGSHEFT Verein Deutscher Ingenieur GmbH Postfach 1139, Graf-Recke Str. 84 4 Duesseldorf 1, Germany	VDI Forsch.
VEHICLE SYSTEMS DYNAMICS Swets and Zeitlinger N.V. 347 B. Herreweg Lisse, The Netherlands	Vehicle Syst. Dyn.
WAVE MOTION North Holland Publishing Co. P.O. Box 211 1000 AE Amsterdam The Netherlands	Wave Motion
WEAR Elsevier Sequoia S.A. P.O. Box 851 1001 Lausanne 1, Switzerland	Wear
ZEITSCHRIFT FÜR ANGEWANDTE MATHEMATIK UND MECHANIK Akademie Verlag GmbH Liepziger Str. 3-4 108 Berlin, Germany	Z. angew. Math. Mech.
ZEITSCHRIFT FÜR FLUGWISSENSCHAFTEN DFVLR D-3300 Braunschweig Flughafen, Postfach 3267 W. Germany	Z. Flugwiss

SECONDARY PUBLICATIONS SCANNED

PUBLICATION AND ADDRESS	ABBREVIATION
GOVERNMENT REPORTS ANNOUNCEMENTS & INDEX NTIS U.S. Dept. of Commerce Springfield, VA 22161	GRA
SCIENTIFIC AND TECHNICAL AEROSPACE REPORTS Superintendent of Documents U.S. Government Printing Office Washington, D.C. 20402	STAR
DISSERTATION ABSTRACTS INTERNATIONAL University Microfilms Ann Arbor, MI 48106	DA

ANNUAL PROCEEDINGS SCANNED

PUBLICATION AND ADDRESS	ABBREVIATION
INSTITUTE OF ENVIRONMENTAL SCIENCES, ANNUAL PROCEEDINGS Institute of Environmental Sciences 940 E. Northwest Highway Mt. Prospect, IL 60056	Inst. Environ. Sci., Proc.
INTERNATIONAL CONGRESS ON ACOUSTICS, ANNUAL PROCEEDINGS	Intl. Cong. Acoust., Proc.
THE SHOCK AND VIBRATION BULLETIN, UNITED STATES NAVAL RESEARCH LABORATORIES, ANNUAL PROCEEDINGS Shock and Vibration Information Center Naval Research Lab., Code 8404 Washington, D.C. 20375	Shock Vib. Bull., U.S. Naval Res. Lab., Proc.

CALENDAR

DECEMBER 1979

Aerospace Meeting [SAE] Los Angeles, CA *(SAE Meeting Dept.)*

2-7 Winter Annual Meeting [ASME] Statler Hilton, New York, NY *(ASME Hq.)*

JANUARY 1980

22-24 Reliability & Maintainability Symposium, San Francisco, CA *(ASME Hq.)*

FEBRUARY 1980

3-7 Energy Technology Conference and Exhibition [ASME] New Orleans, LA *(ASME Hq.)*

19 Current Techniques in Vibration Measurement and Recording [SEE] London, England *(SEE Hq.)*

26-29 Congress & Exposition [SAE] Cobo Hall, Detroit, MI *(SAE Meeting Dept.)*

MARCH 1980

9-13 25th Annual International Gas Turbine Conference and Exhibit [ASME] New Orleans, LA *(ASME Hq.)*

24-27 Design Engineering Conference and Show [ASME] McCormick Place, Chicago, IL *(ASME Hq.)*

APRIL 1980

21-25 Acoustical Society of America, Spring Meeting [ASA] Atlanta, GA *(ASA Hq.)*

MAY 1980

5-8 Offshore Technology Conference, Astrohall, Houston, TX *(ASME Hq.)*

19-23 Fourth International Conference on Pressure Vessel Technology [ASME] London, England *(ASME Hq.)*

25-30 Fourth SESA International Congress on Experimental Mechanics [SESA] The Copley Plaza, Boston, MA *(SESA Hq.)*

JUNE 1980

11 Experimental Techniques for Fatigue Crack Growth Measurement [SEE] British Rail Technical Centre *(SEE Hq.)*

17-19 International Conference on Vibrations in Rotating Machinery [ASME] Cambridge, England *(ASME Hq.)*

22-26 Summer Annual Meeting [ASME] Waldorf-Astoria, New York, NY *(ASME Hq.)*

JULY 1980

7-11 Recent Advances in Structural Dynamics Symp., [Institute of Sound and Vibration Research] University of Southampton, Southampton, S09 5NH, UK *(Mrs. O.G. Hyde, ISVR Conference Secretary, The University, Southampton, S09 5NH, UK - Tel (0703) 559122, Ext 2310)*

OCTOBER 1980

6-8 Computational Methods in Nonlinear Structural and Solid Mechanics [George Washington University & NASA Langley Research Center] Washington, D.C. *(Professor A.K. Noor, The George Washington University, NASA Langley Research Center, MS246, Hampton, VA 23665- Tel (804) 827-2897)*

NOVEMBER 1980

18-21 Acoustical Society of America, Fall Meeting [ASA] Los Angeles, CA *(ASA Hq.)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS: American Federation of Information Processing Societies
210 Summit Ave., Montvale, NJ 07645

AGMA: American Gear Manufacturers Association
1330 Mass. Ave., N.W.
Washington, D.C.

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics, 1290 Sixth Ave.
New York, NY 10019

AIChE: American Institute of Chemical Engineers
345 E. 47th St.
New York, NY 10017

AREA: American Railway Engineering Association
59 E. Van Buren St.
Chicago, IL 60605

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, NY 10017

ASME: American Society of Mechanical Engineers
345 E. 45th St.
New York, NY 10017

ASNT: American Society for Nondestructive Testing
914 Chicago Ave.
Evanston, IL 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave.
Milwaukee, WI 53203

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

CCCAM: Chairman, c/o Dept. ME, Univ. Toronto,
Toronto 5, Ontario, Canada

ICF: International Congress on Fracture
Tohoku Univ.
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IFToMM: International Federation for Theory of Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
400 Stanwix St.
Pittsburgh, PA 15222

ONR: Office of Naval Research
Code 40084, Dept. Navy
Arlington, VA 22217

SAE: Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096

SEE: Society of Environmental Engineers
6 Conduit St.
London W1R 9TG, UK

SESA: Society for Experimental Stress Analysis
21 Bridge Sq.
Westport, CT 06880

SNAME: Society of Naval Architects and Marine Engineers
74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Lab., Code 8404
Washington, D.C. 20375

URSI-USNC: International Union of Radio Science - U.S. National Committee
c/o MIT Lincoln Lab.
Lexington, MA 02173

ZF DEFENSE DOCUMENTATION CENTER
CAMERON STATION
ALEXANDRIA, VA 22314